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INVESTIGATION INTO THE CANADIAN CAPABILITIES FOR METALLIZING

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17. Abstract

A survey has been carried out to determine the Canadian capability for metallizing. The study shows there is considerable experience in Canada. Most companies serve local markets and fall into two categories: those associated with machine shops serving the aircraft, oil and gas, pulp and paper industries, etc. and those offering corrosion control services usually in the field.

The industry is largely supplier driven with the leading suppliers providing complete metallizing systems, procedures, materials, and technical support. Quality control programs vary widely and emphasize different aspects of the metallizing operation. None of the companies operates a system as complete as that used by the US Navy in its aluminum spraying operations.

The main steps needed to provide Canadian Coast Guard with a reliable metallizing delivery system are in the development of a full quality maintenance system including a draft specification, procedures and field practices, qualification, inspection, reporting and training.

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17. Résumé

Une recherche a été effectuée afin de déterminer le potentiel de l'industrie canadienne dans le domaine de la métallisation. Les études démontrent qu'il y a une expérience considérable en la matière au Canada. La majorité des compagnies desservent les marchés locaux; on peut les diviser en deux catégories: celles qui coopèrent avec les ateliers d'usinage travaillant pour les industries aéronautique, pétroliére, des pâtes et papier etc., et celles qui offrent les services de protection contre la corrosion, habituellement sur chantier.

L'industrie de la métallisation est en grande partie contrôlée par les fournisseurs. Les plus importants assurent la livraison des systèmes complets de métallisation ainsi que les procédures, les matériaux et le support technique. Les programmes d'assurance-qualité diffèrent largement et mettent l'accent sur les aspects divers de l'opération de métallisation. Aucune des compagnies ne possède un système aussi complet que celui utilisé par la Marine américaine dans les opérations de métallisation à l'aluminium.

Les étapes principales d'une action visant à doter la Garde côtière canadienne d'une système de métallisation fiable consistent au développement d'un système de la maintenance de haute qualité incluant une ébauche de spécification, les procédures et pratiques d'application, qualification, inspection, établissement des rapports et formation.

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Executive Summary

A survey has been carried out to determine the Canadian capability for metallizing. The study shows there is considerable experience in Canada. Most companies serve local markets and fall into two categories: those associated with machine shops serving the aircraft, oil and gas, pulp and paper industries, etc. and those offering corrosion control services usually in the field. Most firms employ about 2-6 metallizers.

The industry is largely supplier driven with the leading suppliers providing complete metallizing systems, procedures, materials, and technical support. Quality control programs vary widely and emphasize different aspects of the metallizing operation. For example, the corrosion control companies place greater emphasis on blast specifications whereas the machine shops have better material quality control. None of the companies operates a system as complete as that used by the US Navy in its aluminum spraying operations.

The main steps needed to provide Canadian Coast Guard with a reliable metallizing delivery system are in the development of a full quality maintenance system including a draft specification, procedures and field practices, qualification, inspection, reporting and training.

Le potentiel de la métallisation au Canada

Résumé

Une recherche a été effectuée afin de déterminer le potentiel de l'industrie canadienne dans le domaine de la métallisation. Les études démontrent qu'il y a une expérience considérable en la matière au Canada. La majorité des compagnies desservent les marchés locaux; on peut les diviser en deux catégories: celles qui coopèrent avec les ateliers d'usinage travaillant pour les industries aéronautique, pétroliére, des pâtes et papier etc., et celles qui offrent les services de protection contre la corrosion, habituellement sur chantier. La plupart des compagnies emploient deux à six opérateurs.

L'industrie de la métallisation est en grande partie contrôlée par les fournisseurs. Les plus importants assurent la livraison des systèmes complets de métallisation ainsi que les procédures, les matériaux et le support technique. Les programmes d'assurance-qualité diffèrent largement et mettent l'accent sur les aspects divers de l'opération de métallisation. A titre d'exemple, les compagnies oeuvrant dans le domaine de protection contre la corrosion attachent plus d'importance aux spécifications de nettoyage au jet d'abrasif, tandis que les ateliers d'usinage se distinguent par un meilleur contrôle des matériaux. Aucune des compagnies ne possède un système aussi complet que celui utilisé par la Marine américaine dans les opérations de métallisation à l'aluminium.

Les étapes principales d'une action visant à doter la Garde côtière canadienne d'une système de métallisation fiable consistent au développement d'un système de la maintenance de haute qualité incluant une ébauche de spécification, les procédures et pratiques d'application, qualification, inspection, établissement des rapports et formation.

Contents

Introduction 1
Background 1
Methodology 3
System elements 3
Existing standards 3
General survey 8
Specific survey 9
General discussion 9
Quality assurance systems 13
Cleaning 14
Blasting 14
Spraying 16
Training 18
Cost analysis 20
Canadian Coast Guard application 22
Conclusions 23
References 25
Appendix A, Standards relevant to thermal spraying 26
Appendix B, List of companies surveyed 27
Appendix D, Report of visits 29

INVESTIGATION INTO THE CANADIAN CAPABILITIES FOR METALLIZING

DSS Contract Number 23440-0-9184/01-SQ

Introduction

There has been growing interest on the part of the Canadian Coast-Guard (CCG) in the use of metallizing for enhancing the life of ships and ship components. Experience in other countries has shown that significant improvements in corrosion resistance of shipboard structures can be achieved by the use of aluminum metallizing. CCG has been working with the Metals Technologies Laboratories (MTL) of CANMET to investigate the use of metallizing to protect ships from corrosion both above and below the waterline[1]. In particular there is interest in protecting the below-waterline welds on icebreakers from corrosion. Laboratory tests are now under way to determine the effectiveness of various coating systems. In addition to corrosion protection CCG also has an interest in the use of metallizing for repair and life enhancement of ship components such as shafts and pumps. In order for CCG to apply metallizing in a major way on ships, there must be an effective and reliable delivery system for metallizing services. The present project was therefore carried out to determine the capability within Canada for undertaking metallizing and to identify what steps need to be taken to ensure a reliable delivery system existed. This report presents the results of this study.

Background

Metallizing is the term commonly used for a class of thermal spray processes (TSP) for depositing metals. Thermal spray processes cover a broad range of processes for depositing layers of various materials over a substrate by spraying at high temperatures. The materials may be metals, hard facing, ceramics, plastics, etc. The three basic methods for thermal spraying materiasls are flame, arc, and plasma. There are a number of variations of the flame system such as hypersonic combustion designed to increase the spray velocity and temperature. Conventional flame spraying with a solid wire feed has traditionally been used for aluminum and zinc for corrosion protection systems[2] although powder systems are now also in wide use. The more recently developed plasma system using powder feed has been preferred for refractory materials, hard facing, and ceramics.

The coating layer deposited by metallizing mechanically adheres to the substrate. There is no direct fusion of the substrate as in welding. Preparation of the surface can therefore have a critical effect on the quality of the bond. Preparation normally requires abrasive blasting to white metal to form a suitable anchor-tooth pattern.

Typical equipment for flame spraying is shown in Fig. 1 and includes gas and air flow controls. The nozzle is held 8-10 inches from the workpiece while spraying. Normal practice is to spray in orthogonal directions to build up the coating in layers.

The metal sprayed coating is porous and for many applications is sealed after deposition.

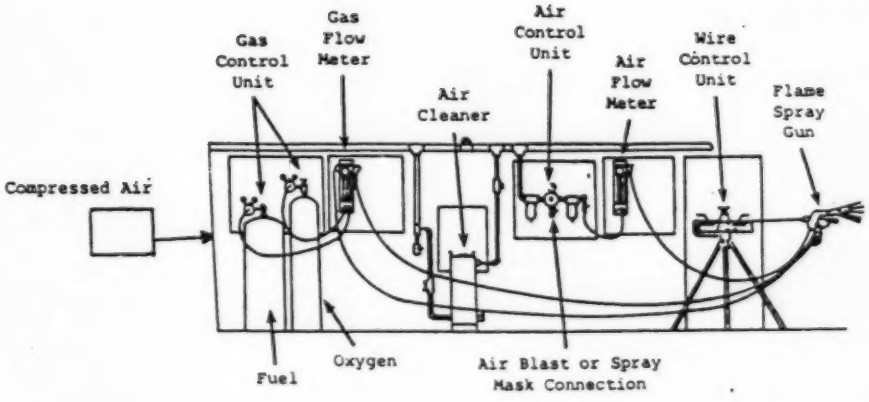


Figure 1. Typical set-up for metal spray system.

Methodology

The main method used in this project was to collect information by direct interview. This was done at two levels, a) a general survey in which telephone interviews were carried out with the majority of metallizing companies identified in Canada, and b) a specific survey entailing visits to about eleven of these companies. To provide a framework for these interviews a check list of elements of a delivery system was established on the basis of preliminary interviews and technical information contained in the literature. Using this approach, it was possible to identify potential weak points in the delivery systems as they currently exist in Canada.

System elements

Metallizing comprises the following major steps: cleaning, blasting, spraying, sealing. (The final step—sealing—is a conventional coating or painting operation and has not been explored in detail in the present project). Each of the main steps has been analyzed on the basis of technical information in the literature and from interviews to determine operating parameters and variables and to identify those that are particularly critical. From this it is possible to determine what has to be specified and what has to be measured to ensure that these steps are undertaken correctly. The system elements are therefore divided into four categories: facilities, procedures, inspection, and personnel. The resulting checklist for each of the steps that was used as the framework for interviews is given in Table 1.

Existing standards

Prior to conducting interviews an effort was made to determine whether national standards already existed for metallizing. Both AWS (American Welding Society) and CSA (Canadian Standards Association) have had standards on metallizing for many years:

- AWS C2.2–67 "Recommended Practices for Metallizing with Aluminum and Zinc for Protection of Iron and Steel," AWS Miami, FL 1967.
- CSA G189–1966(1980) "Sprayed Metal Coatings for Atmospheric Corrosion Protection," CSA Rexdale, 1966.

Both of these, however, are fairly general and do not appear to be widely used.

CSA G189 covers aluminum and zinc in wire or powder form. Purity of the material is specified. Blasting to white metal is required but no specific profile or anchor pattern is detailed. An appendix provides some guidance on abrasive materials and recommends silica sand for both zinc and aluminum.

The time between blasting and spraying is limited to 4 hours unless visible deterioration of the surface has occurred earlier. A minimum nominal thickness of 0.004 inch (and minimum local thickness of 0.0036 incl.) is speci-

Table 1. Guideline for System Requirements for Metallizing.

Step	Facilities	Procedures	Inspection	Personnel
Cleaning	Solvents Tanks Oven heating UV lights Gloves, clothing Masking Ventilation	Basis for selecting cleaning method. Cleaning procedure. Handling procedure. Safety requirements. Identification of components. Approval of procedures.	Visual. Cloth wipe. Black light (UV). Inspection record.	Training in using solvents, safety procedures.
Blasting	Masking materials. Air supply. Dryers, dessicators, oil separators. Blast room. Blast equipment. Grit reclaiming system. Personal protection, clothing. Breathing air.	Procedure for masking. Procedures for blasting. SSPC-SP5 white metal. Humiditiy limits. temperature limits. Handling procedure. Time limit to spraying. Qualification/approval of procedures.	Visual check for masking. Sample test for initial set-up (eg Press-o-film). Visual and sample test for anchor-tooth profile. Verify air quality and dew point. Checking grit/oil cleanness and fines.	Training in safety procedures. Qualification by test to produce required surface.
Spraying	Air supply. Air cleaning. Controls for air and gas. Spraying equipment. Spray booth or protection from elements. Protective gear. Testing equipment. Electrical facilities. Storage of materials.	Specification of materials. Spray procedure. Coating thickness. Humidity and temperature limits. Preheating. Qualification by test and approval.	Visual (X10). Thickness gauge. Sample bend test. Knife-peel test. Adhesion test. Metallography. Identification of samples. Inspection report.	Qualification of operators through training program (application specific) and testing.

fied for both zinc and aluminum. Testing of the final coating is by magnetic or electro-magnetic gauge for thickness and the knife-peel test for adhesion. The latter test involves scribing a 2 inch line with a sharp knife and attempting to lift the coating from the substrate. No part of the coating larger than 0.5×0.5 inch shall be lifted.

The most fully developed specification appears to be the U.S. Navy Specification for wire sprayed aluminum. This specification is a result of an extensive development program over many years to set up reliable delivery systems for aluminum metallizing for corrosion control in the U.S. Navy. It was originally issued in November 1981 and subsequently reissued in ammended form in a draft dated 23 April 1986 as DOD–STD–2138A(SM) "Metal Sprayed Coatings for Corrosion Protection Aboard Naval Surface Ships (Metric)." It is a comprehensive document covering procedures and control systems. The scope of the document is limited to wire sprayed aluminum coatings although the U.S. Navy are also using aluminum powder systems. Some of the key features are summarized below:

- An extensive section deals with safety precautions including solvents, spray gases, blasting, respiratory hazards, clothing, noise, eye protection, and compressed air.
- Pressure blasting (as opposed to suction or centrifugal blasting) is required for large area production work. Minimum air pressure at the blast nozzle for aluminum oxide is 350 kPa (50 lb/in^2). Air quality is specified in tems of maximum hydrocarbon contamination and maximum water content (10°C dew point). No separated water is permitted. Tests for separated water are conducted prior to each shift.
- Trichloroethane (spec. 0–T–620) or xylene (ASTM D846) are permitted as cleaning solvents. Other details of cleaning procedures are given.
- Only aluminum oxide grit (mesh 16-30) or angular chilled iron grit (mesh 25-40) are permitted on steel (only aluminum oxide on aluminum) for the production of the final anchor tooth pattern. Other inexpensive abrasives may be used for preliminary abrasive cleaning.
- A final anchor tooth pattern of 50-75 µm (2-3 mils) is required. Prior to reuse aluminum oxide shall be screened and pass an oil contamination procedure. Blasting is to a white metal finish (SSPC SP5). The profile is measured with profile tape and a dial micrometer (Fig. 2).
- Wire spraying is with the oxy-acetylene flame spray process. The metal surface must be 5°C (10°F) above the dew point and spray must start within 4 hours and finish within 6 hours of blasting. Details of spray technique are given.
- Seal coats are required according to application.
- A full section covers certification and qualification requirements. Certification of facilities involves meeting minimum equipment requirements, qualification of procedures through testing, and qualification of personnel through testing. Testing involves making test panels which are subject to:

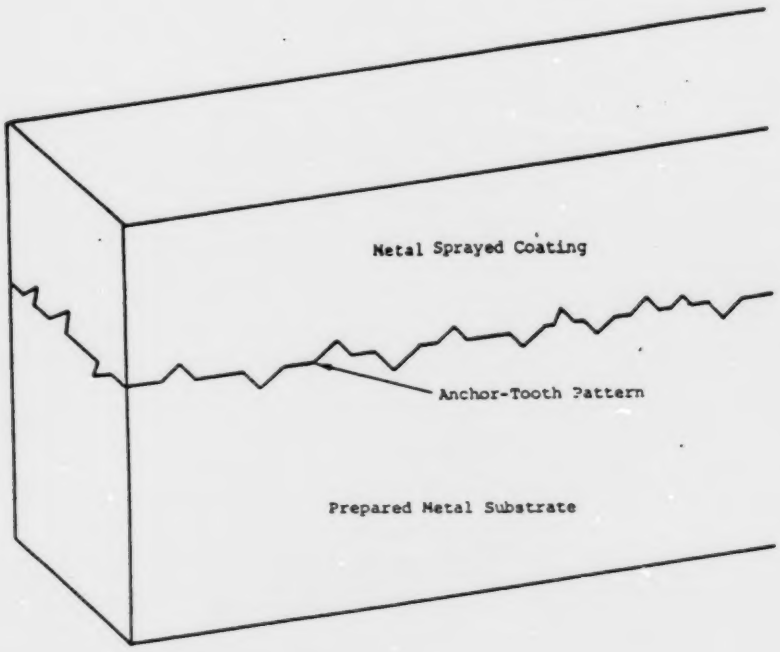


Figure 2. Profile of anchor-tooth pattern (DOD-STD-2138A(SH)

1) Visual examination (no blisters, cracks, chips, oil, contaminants, or pits that expose the substrate);
2) Bend tests;
3) Bond tests (ASTM C633) meeting an average strength of 13.8 MPa (2,000 psi) and minimum of 10.3 MPa (1,500 psi);
4) Shape test. Thickness between 0.25 to 0.40 mm (10-15 mils).

- Production quality assurance requirements are detailed. Production records are specified and an example is given in Fig. 3. Production samples (panels sprayed at the same time as the job) are required and are evaluated by bend testing. The job itself may be subject to the knife-peel or adhesion test. No part of the coating may lift in the knife-peel test. Minimum strength in the adhesion test is 6.9 MPa.

1. Job control number _____ 2. Date _____

3. Ship system _____ 4. System component _____

5. Area to be sprayed _____

6. Masking information (area not to be sprayed) _____

7. Base material (type) _____

8. Preparation methods:

   Cleaning: Degrease solvent: _____
   Oven bake: temp _____; time _____

   Rough blasting: Grit type and size: _____

   Anchor-tooth blasting: Grit type, size, and profile: _____
   _____

   Masking information _____

9. Thermal sprayed coating (type and thickness) _____
   _____

10. Seal coat (types and thicknesses) _____
    _____

11. Top coat (type) _____

    Inspection procedures and results:

    Visual examination (inspector initial) _____
    _____

    Thickness measurement (inspector initial) _____
    _____

    Knife peel test (inspector initial) _____
    _____

    Item accepted? (Yes/No)

    Sprayer's identification:

    Name/number _____

    Inspector's identification:

    Name/number _____

Figure 3. Example of production record required by DOD-STD-2138A(SH).

The Steel Structures Painting Council (SPC) which is one of the leading organizations developing standards for the painting industry is currently developing a standard for metallizing:

- SSPC PS–XMETOIX–90P "Thermal Spray Metallic Coating System."

A review of an unpublished draft of the standard suggests that it will lean heavily on the U.S. Navy document. The SSPC document will cover zinc, aluminum, and zinc/aluminum alloys and will provide a useful guide for the preparation of specifications.

In addition SSPC standards for blast finishes have been used for many years:

- SSPC–SP5 White Metal Blast Cleaning
- SSPC–SP10 Near-White Blast Cleaning
- SSPC–Vis 1–89 Visual Standard for Abrasive Blast Cleaning.

Other national standards are applicable to some of the peripheral activities associated with metallizing. For example, ASTM C633 covers the tension test for evaluating bond strengths. A list of relevant standards is given in Appendix A.

General survey

An attempt was made to establish a list of the substantial majority of companies offering metallizing services in Canada. It was recognized that many companies might use metallizing as an internal operation as part of their production but would not be in the business of offering services. For example, Air Canada has 33 metal spray booths at its Dorval facility but is not considered a metal spraying contractor. Such companies were not included in the survey.

Statistics Canada Publication "Manufacturing Industries in Canada" 1980, lists 240 companies in Canada under Group 13-3041 Metal Coating Industry. In the newer classification this is split into 2 SIC (Standard Industrial Classification) Nos. 3471 Electroplating, Plating, Polishing, Anodizing, and 3479 Coating, Engraving and Allied Services and Other Coating Services, and in 1988 there were 436 names listed in Ontario under both these classifications. Since these would include metal finishers and electroplating companies it was initially estimated that there might be approximately 100 metallizing companies in Canada. Since this was in the range of a manual search, it was decided to compile a list directly by a manual search of telephone directories for all regions in Canada. This was supplemented by a manual search of trade directories followed by about 200 screening calls which showed that only 10% of the companies under the two SIC classifications did metallizing. Additional names were added to the list as the survey progressed based on personal contacts,

discussion with suppliers, and published buyers guides.

Telephone interviews were carried out with these companies, some of which could not be reached and some who were no longer in business, and many of the companies, although listed as metallizing, were not undertaking thermal spraying of the type relevant to this project. For example, some were using electrostatic or vacuum systems of deposition. The final list of companies undertaking thermal spraying was 66 and is believed to cover the substantial majority of those companies offering metallizing services in Canada. This is given in Appendix B.

The instrument used for conducting the general survey is shown in Fig. 4. Detailed responses were recorded manually and results were summarized in code form for entry into the computer database which facilitated subsequent analysis.

Specific survey

Eleven companies were selected for visits on the basis of information obtained from the general survey. Companies were selected to represent a cross-section of industries served, size of company, and region. The selection of a company for the specific survey does not constitute a recommendation and the visits should not be regarded as formal audits. The purpose was to obtain more information for characterizing the overall Canadian capability for metallizing. Visits took place from the 1st-15th February. A brief summary report of each visit is included in Appendix C.

General discussion

The results of the survey indicate that although there are many companies in Canada doing metallizing most of them serve a local market. There are very few companies that could be considered national companies. Figs. 5 and 6 show the distribution of company size and distribution according to personnel involved directly in metallizing. There is a reasonable even distribution in terms of company size but regardless of size the metallizing operations in most companies tend to employ two to six people The only cases where larger numbers are employed are corrosion control companies undertaking large field-work and there employment is seasonal.

About half the companies offer field services and a similar proportion have undertaken marine work at some time (Figs. 7, 8). About half the companies have an engineer on staff or retain one. All companies also use suppliers extensively for technical support (Fig. 9). Fig. 10 shows the proportion that currently spray or have sprayed aluminum or zinc. Only a small proportion have no experience with these materials.

Metallizing Survey Instrument

Company: Tel:
Address: FAX:

City: Prov: Code:

Good morning/afternoon, may I speak to a technical person regarding metallizing?

Good morning/afternoon, may name is ------ and we are assisting the Canadian Coast Guard to identify companies that may be able to offer metallizing services. May I ask you a few questions about your metallizing operations?

To whom am I speaking? Contact:

Which processes do you use?
Flame spraying
Arc spraying
Plasma
Other

Which materials do you use?
Zinc
Aluminum
Other

Where do you offer services?
In the shop only
Portable services in the field

Have you undertaken any marine applications in the past two years? (Could you describe them)

What other applications have you done?

How many people in your company?

How many involved in thermal spraying?

How are your personnel trained?
On the job training
Equipment supplier training
Other

Who do you rely on for technical support?
Engineer(s) on staff
Equipment suppliers
Other

How do you do the surface preparation?
Send out for blasting
Do your own blasting
Other

What standards or specifications do you work to?

How do you inspect the coating?
Visual only
Thickness gauge
Mechanical tests
Metallographic tests
Other

What other quality control procedures do you use?

May I check your address, phone and FAX number?

Thank you very much for your help.

Figure 4. Instrument used for the general survey.

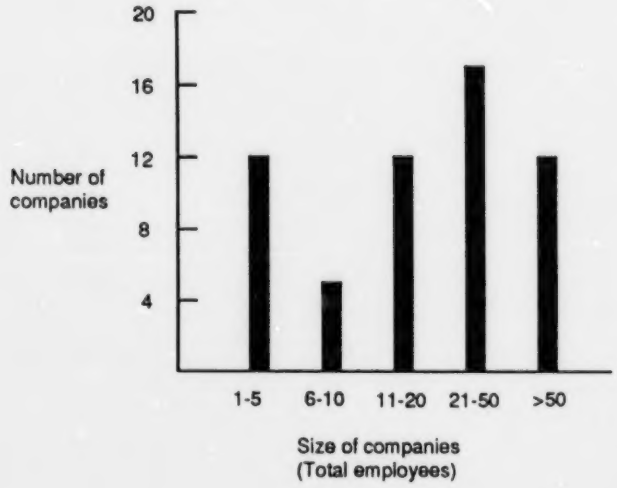


Figure 5. Distribution of companies by size (total number of employees).

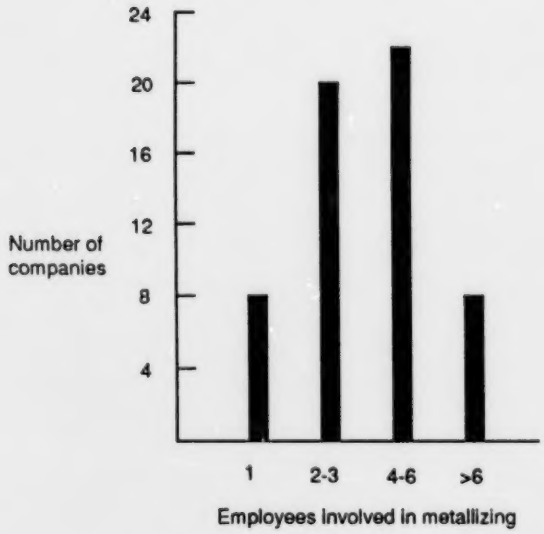


Figure 6. Distribution of companies by number of employees doing metallizing.

Figure 7. Companies offering field services.

Figure 8. Companies that have done marine work.

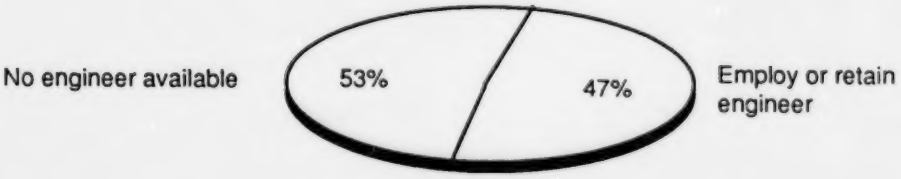


Figure 9. Companies having an engineer.

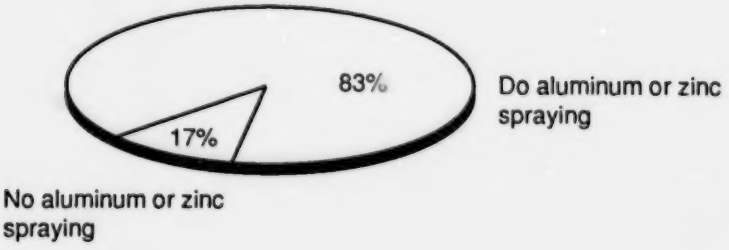


Figure 10. Companies with aluminum/zinc experience.

Most of the companies have grown up around specific industries in particular locations. For example, in southern Ontario companies serve the steel industry; in Montreal and Winnipeg companies serve the aerospace industry; in Edmonton, the oil industry. This is because the cost of shipping components large distances for metallizing would be uneconomical. Where there has been sufficient demand it has been more economical to set up shop locally.

Surprisingly very few companies are located in the Atlantic provinces. It is quite possible that this is because there has been no large scale demand for metallizing services to warrant full time operations. It is likely therefore, that there are several companies in the region that have metallizing equipment and have done metallizing in the past as required but do not do it as their main line of business. This situation could change in the Atlantic provinces if large scale projects such as Hibernia warrant full time operations.

Quality Assurance Systems

There is a considerable variation in the type and sophistication of quality assurance systems used by the various metallizing companies visited. None of the companies use systems as complete as that required in the U.S. Navy program[3] and there are a number of reasons for this. First, many shops are undertaking less sophisticated work for a variety of customers and a complex system is not deemed justifiable.

Second, some companies work closely with a particular customer who provides procedures, approvals, and technical support. They therefore become a trusted supplier through an informal system of monitoring. It was noted during the visits that for shop work the main control system was direct supervision by a technical manager.

Third, the wide variety of applications, the relatively small size of the industry, and the strong presence of the equipment suppliers in providing procedures, training, and technical support has meant that national standards have been slow to develop.

In most cases companies have a written procedure for metallizing. These are obtained either from the customer or from the equipment supplier. Usually procedures are approved by customers either through bid acceptance or a separate procedure approval phase. Only in a very few cases is approval dependent on conducting tests. Where tests are required they generally take the form of test panels which are sprayed and submitted to the customer for detailed evaluation.

Metallizing companies tend to fall into two goups: those associated with machine shops and those associated with painting companies. The former do work mostly in shops on relatively small components. A wide range of coat-

ings is applied to achieve various wear, abrasion, thermal, or other properties. Since most components are machined after coating the coating is effectively subject to a mechanical test. If the coating survives the machining it is likely to have a reasonable bond strength. Thus poor coatings are revealed early on and can be corrected before the job leaves the shop.

The painting companies and others that specialize in corrosion control work on large areas generally in the field. Coatings are not machined and a poor coating may not be revealed until a coating failure occurs some time after the structure is put into service.

The difference between these two groups of applications has resulted in different strategies evolving for quality control. There is a different emphasis on the various stages of the metallizing process. A common practice in companies doing work for the aerospace industry is to issue a 'Certificate of Compliance' that states that spraying was done according to the specified procedures. In the following sections the results of the survey will be discussed in the context of each of the steps, particularly in respect to the quality control methods.

Cleaning

A variety of methods are used for cleaning and are application specific. Steam cleaning is used in large field shops and solvents are common for shop work. Special methods, such as acid dipping, may be required to remove previous coatings. Castings cause problems because of oil seepage from pores and baking is often required. Inspection following cleaning is visual or wiping with a cloth to ensure that contaminants and moisture have been removed.

Blasting

Without exception spraying is preceded by abrasive blast cleaning but procedures differ among various companies. In all cases the significance of moisture and contamination is appreciated and steps taken to minimize problems. Most compressors have reservoirs or dessicators to collect moisture and allow temperature equalization. But in no case are there any definitive tests for air dew point or oil content. It was pointed out during interviews that condensation is quite apparent and that visual checks are considered adequate. Moisture can become a serious problem and field work is often prohibited when the relative humidity exceeds (say) 85%. Such limits are written into specifications for spraying of bridges and other large outdoor structures.

Most painting companies use silica sand for blasting because of the cost whereas many of the machine shop facilities use aluminum oxide. Several other materials such as black slag (a copper slag), 'black beauty' or 'white lightening' are in use. Silica sand is inexpensive which is an important consideration for field work where recycling may not be feasible. For health reasons, silica sand is now restricted (it is a designated substance in some provinces) and

is less commonly used in shop operations.

The profile formed depends on the abrasive used and some materials (e.g., shot) peen the surface rather than create an anchor-tooth pattern. For spraying aluminum an aluminum oxide abrasive is generally recommended. Some companies use silica sand even when spraying aluminum but admit that aluminum is fussier about the surface than zinc. If aluminum oxide is specified for a field job the cost can become significant. One price quoted was $120 per bag of aluminum oxide versus $6 per bag for silica sand. Obviously there is a strong incentive to use recycling systems even for field work.

If the abrasive is recycled it deteriorates and the proportion of fines increases. After reuse several times it is unable to produce the correct profile. It does not appear, however, that companies perform tests to evaluate the abrasive. From what was observed the normal practice is to recycle until a visually unacceptable blast surface is obtained or it takes too long to achieve an adequate surface. In some cases no recycling is permitted.

Almost all specifications call for blasting to white metal but in few cases is this defined or measured in any way. The painting companies usually specify the surface in terms of the SSPC standards, e.g., SSPC SP5 for white metal, and these are inspected using the Swedish pictorial comparison standards. In one case, it is the practice of the company to run a sample at the beginning of the job to act as a reference standard.

Although the anchor-tooth profile is recognized as important, in few cases is this measured on a regular basis. Most companies are familiar with the measurement methods using profile tape but are rarely required to perform the tests. The painting companies appear to do these tests on a more frequent basis.

Some problems have been experienced on structural work where hardness differences exist in the metal. In one example, flame cutting of thick steel had been performed without preheat, resulting in a hardened heat affected zone. Blasting with silica sand failed to produce a suitable anchor pattern which resulted in a poor coating bond at the edge. The solution was to use preheat for flame cutting but it was admitted that the problem might not have occurred if aluminum oxide had been used for blasting.

Time between blasting and spraying was indicated in all the interviews as an important parameter. The elapse times specified in procedures vary from one to eight hours according to application. But few companies have formal systems for controlling it or means by which customers could verify it. One reason is that the size of components is relatively small and the normal progress of work ensures that spraying is completed within a short period of blasting.

On large jobs the time is controlled by dividing the job into smaller areas. A crew starts the blasting and is then followed by the sprayer. The blasting crew ensures it does not get too far ahead of the spraying crew.

When spraying in sections like this there is a region of overlap. This generally causes no problem and the coating thickness is controlled by 'feathering' the edge of the previously sprayed region.

Spraying

Equipment for thermal spraying is purchased as a system as shown, for example, in Fig. 1. It is provided with the necessary air cleaners, separators, control valves, etc. All companies interviewed had equipment bought as complete systems from the major suppliers. Occasionally modifications are made to the head for spraying odd geometries. Only flame and arc spraying are suitable for field use and the flame methods have the added advantage of not requiring electricity.

At present there are no effective means of non-destructively testing thermal sprayed coatings although considerable research effort is being spent on special ultrasonic and thermal imaging systems. Conventional ultrasonics is useful for finding large pores in thick coatings but will not indicate the quality of the bond. In the majority of cases, therefore, there is no direct testing of the finished coating. For many applications spraying is followed by machining which itself provides a kind of mechanical test. Thus a poor bond might reveal itself as flaking or pealing during the machining operation. For unmachined corrosion control applications, such as zinc or aluminum spraying of large structures, a poor bond might not show up for several years.

The major methods for assuring coating quality are control samples and informal tests. Control samples are extensively used by one of the companies for aerospace applications and are often used by the corrosion control companies. On complex shapes samples may not be representative since the component might have odd corners and edges needing spraying in awkward positions whereas the sample is a flat plate. For large area structures the samples should be quite representative as long as they are made from the same material and blasted with the same procedure. This is not always possible if spraying is being done on an existing structure that has been in service and in such cases testing of the coating on the actual structure followed by local repair may be warranted.

Mechanical testing of samples can include bend testing (shown in Fig. 11) or adhesion strength testing. The latter is accomplished with a pulling device that measures the tension strength of the coating bond (Fig. 12). Informal tests, such as manualiy pulling off adhesive tape or scraping with a screwdriver similar to the knife-peel test, are commonly done.

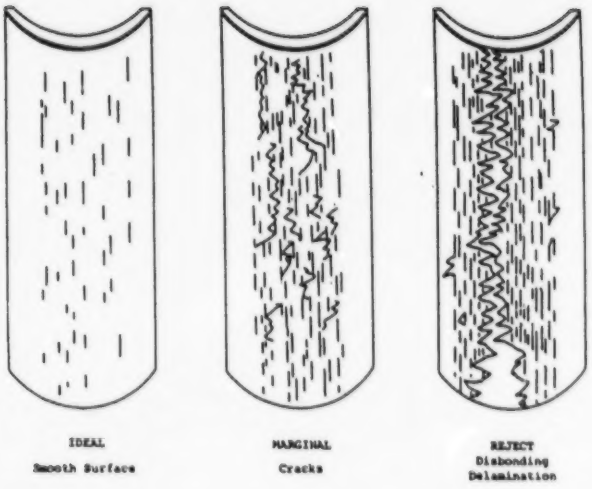


Figure 11. Coupon bend test showing typical results.

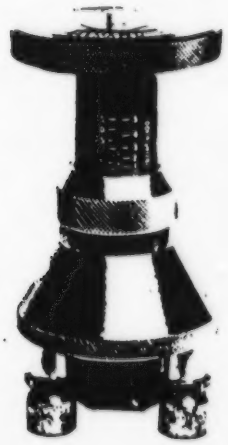


Figure 12. Device for tensile adhesion test (Elcometer).

The most common inspection method for final coatings is simply a visual inspection followed by dimensional checks. The latter comprise overall dimensions for those components being finish machined or ground and thickness measurements. Thickness is measured with magnetic, electromagnetic, or ultrasonic devices. Some machine shops might also have to meet profile requirements on finished coatings such as specified root mean square (r.m.s.).

For special coatings, especially in the aircraft industry, metallographic examination is widely used. This is done by the customer or by an external laboratory since none of the companies visited currently have their own laboratories. Metallographic examinations is done during the evaluation of proposed procedures or on samples prior to start-up but is not used as a routine control on production work.

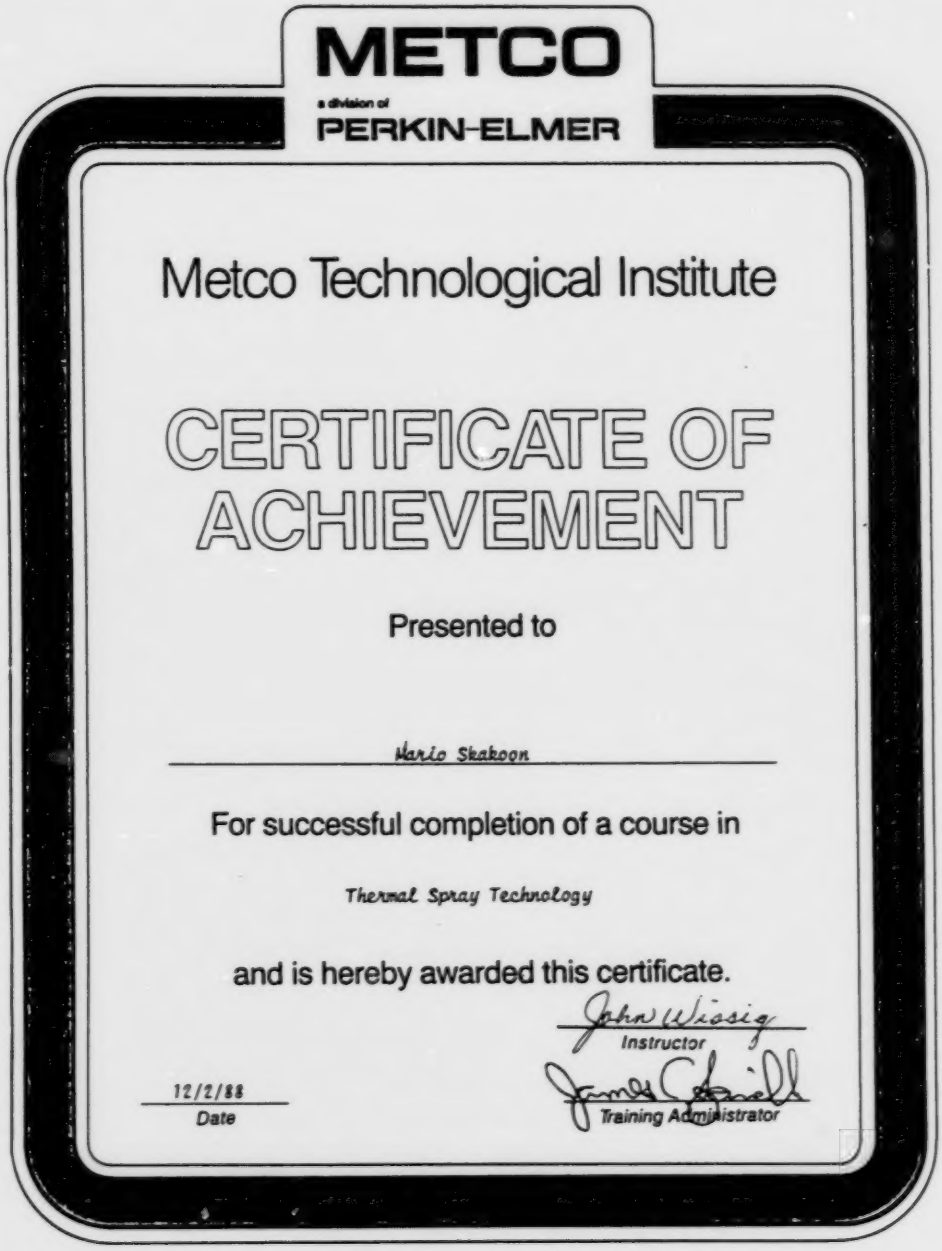
All of the companies surveyed have systems for controlling the materials used. These are usually specified in the customer's order or in the prepared procedures. In many cases proprietary systems are called for and the material specified by its trade name. This is particularly so for powder systems which are often not known by generic terms or covered by near proprietary specifications.

Many companies, and especially those doing work for the aerospace industry, record lot and batch numbers of all materials used as customers require traceability of materials. These are documented on the certificate of compliance or final inspection report. In a few cases batches are certified by conducting tests. Certified batches are stored separately in a heated storeroom.

Training

Metal spraying is not a regulated trade in any of the provinces and there is no national training system. The number of personnel required is small and has generally not warranted training programs from colleges, although apparently Niagara College in Ontario had put on a course of metal spraying a few years ago. Neither do there appear to be any training programs offered by independent training organizations, again presumably because of the small numbers.

Most training has been by the equipment suppliers, which would naturally be equipment specific. For example, several of the people interviewed in the visits had taken courses at Metco's Technological Institute in New York (see sample of certificate in Fig. 13). All companies visited claim they do in-house training but there is little evidence that this is formal or that personnel are qualified on the basis of meeting defined standards. The usual practice is to train through a system of job progression. Skills are learned on the job and sprayers initially gain experience on less critical jobs before moving on to more demanding applications. In many shop situations, too, spraying is done automatically so skills become less a question of manipulative technique and more a



METCO
a division of
PERKIN-ELMER

Metco Technological Institute

CERTIFICATE OF ACHIEVEMENT

Presented to

Mario Skakoon

For successful completion of a course in

Thermal Spray Technology

and is hereby awarded this certificate.

John Wiosig
Instructor

12/2/88
Date

Training Administrator

Figure 13. Example of certificate issued from supplier training program.

challenge of equipment setup and procedure selection.

Where metallizing is being applied manually it was pointed out that machinists tend to make better metallizers than welders. Although this cannot be taken as a generalization, it does suggest that the skill set required for metallizing differs significantly from that acquired from welding.

Somewhat surprising in the survey was the observation that operator qualification by the customer is very rarely undertaken. Only in one case where work is being done for the aerospace industry does the customer require operators to perform tests and issue certificates on the basis of the results. In a few other cases it was learned that the customer might ask for evidence of experience but no other proof of competency. This situation is quite different from the welding industry where welder qualification is invariably required on major structures and presumably reflects the idea that metallizing is less critical having little effect on structural integrity. On the other hand, if an expensive metallizing job has been justified on a twenty year life, the economic consequences of a failure could be serious and it would seem that qualification of operators would be quite justified. Of course, most companies do not risk their reputation by using incompetent operators but some industry observers commented on the possibility of 'fly-by-night' outfits that could perform poor work that might not be discovered for a few years.

At present the small numbers of individuals involved in metallizing and the large number of different applications suggest that a national scheme for qualification and certification of operators is unlikely to be developed in the near future. It is therefore up to individual clients to initiate qualification schemes if they feel the application warrants it.

Cost analysis

The wide range of applications makes a reliable cost analysis difficult to do but a general comparison is presented as a guide. Coupled with available data on life expectancy this provides a general basis for justification or at least serious consideration of metallizing as an option in a corrosion control strategy. The application considered would be for a large area structure (such as a ship hull) coated in the field. Field work substantially increases the cost and it should be noted that if difficult field conditions exist (for example, working high up or in wet environments) where special facilities are required, the incremental cost might have to be added to both metallizing and conventional coating. Under such conditions the relative cost difference narrows.

Some relative costs are reported in the literature for specific applications[3, 4, 5]. One report suggests that application costs for painting, arc, or flame spraying are all within 15% of each other. In practice, however, differences are likely to be far greater for several reasons. First, aluminum metal

spray requires a sealing coat thereby introducing extra spraying steps. Second, more expensive aluminum oxide is required for grit blasting before thermal spraying. One source quoted $120 per bag of aluminum oxide compared with $6 per bag for silica sand. There is, therefore, a strong incentive to use recycling systems for aluminum oxide grit. U.S. Navy figures suggest these factors could raise the cost another 10-30%.

One source quoted job figures of $2.80 per sq. ft for painting versus $4.31 sq. ft for metallizing with zinc for a specific job. These were thought to be at the low end and may not include certain field costs. Another source indicated that typical figures for field application are $3.50 per sq. ft (paint) versus $6.50 per sq. ft (zinc). The general conclusion was that thermal spraying with zinc would cost about twice that for painting.

Costs for spraying aluminum would be expected to be somewhat higher because of surface preparation costs, seal coating, etc., and the additional qualification and compliance costs that might be necessary. The sprayed aluminum could cost more than twice conventional paint systems.

Experience to date suggests that very long life may be expected from thermally sprayed aluminum. The U.S. Navy program started in 1977 and regular monitoring shows effective corrosion protection to date although there are no below waterline applications. The AWS Nineteen Year Report indicates that aluminum may provide a twenty year life in a hostile marine environment. Ship loaders at bulk terminals in B.C. were sprayed in 1966 and apparently show no signs of corrosion.

The hulls of a number of small boats (fishing boats, cutters, yachts, etc.) have been thermally sprayed mainly using zinc. Experience shows that this provides better tolerance to mechanical damage of the coating than conventional paint coatings, thus lowering the risk of premature coating failure. Estimates from a number of sources suggested that conventional coatings might have a life of 2~5 years but the type of coating and service conditions greatly affect this.

Based on thse estimates (and neglecting financing costs) it is concluded that thermal sprayed aluminum coatings would be cost effective even up to three times the cost of conventional coatings. In fact, discussions with industry sources suggest that the difficulty in getting metallizing accepted is not the life cycle cost justification but the long amortization periods (20 years). Apparently it is easier to justify a lower cost over five years than a single higher cost for twenty years.

Canadian Coast Guard Applications

CCG has indicated an interest in two broad areas of application. First, there is the conventional use of thermal spraying in the repair and maintenance of components such as shafts, pumps, etc. This is a well established use and many companies do this class of work on a routine basis. Most companies serve a local area supported by a specific industry (e.g., steel or oil and gas) but several undertake field work when necessary.

The second is for corrosion control with particular interest in the protection of below-waterline welds. Systems being considered are based on aluminum or aluminum alloys. Aluminum requires sealing following application and for below water use an antifouling coating may be required. Apparently zinc is far more resistant to marine buildup (barnacles, etc.) than aluminum and this would be a consideration in final coating selection. Compromises such as 85% Zn, 15% Al are being evaluated.

The survey indicated that although there is considerable experience in field spraying of zinc there is less experience with aluminum. Several large structures (e.g., ship loaders) have been coated with aluminum and there has been limited use on small boat hulls but zinc is the more common material for bridges and other structural applications. Since metallizing of a hull is carried out in a shipyard dry-dock the environment would demand considerable field experience. Heated enclosures may be required to control humidity. It may be beneficial to use self-contained units such as the one shown in Fig. 14.

The cost analysis discussed previously suggests the high initial cost is justified on account of the long expected life. It is imperative, therefore, that the risk of a premature coating failure is minimized. Since there is no effective way of non-destructively testing the finished coating, confidence in the final product must be generated through a comprehensive quality maintenance program. This has been the approach in the U.S. Navy and the same principles apply to large-scale CCG applications.

Much of the work in the U.S. Navy program in setting up the control systems was undertaken by Integrated Systems Analysts, Inc. and the documentation provides a useful basis for developing a system for Canadian use. The survey revealed that no companies are using control systems as detailed and extensive as those used in the U.S. Navy program but most companies use at least some of the elements of the quality control program. The basic facilities, experience, and technical skills for metallizing exist in several companies in Canada and the major requirement for a reliable delivery system is the quality maintenance program. The major steps that need to be taken are therefore:

- Develop a draft specification based on technical requirements.
- Develop detailed procedures and field practices.

- Establish a quality maintenance program including procedures, qualification methods, recording, inspection, and reporting.
- Develop a training program and qualification system.

Development of the documents should involve direct input from the suppliers and the coating companies particularly in regard to field practices.

In the U.S. Navy program similar steps were taken and much of this was undertaken by Integrated Systems Analysts, Inc. The survey in Canada shows that much of the material exists with most companies using at least some elements of the quality control program.

Conclusions

A survey has been carried out to determine the Canadian capability for metallizing with specific reference to Canadian Coast Guard needs. The study has provided a list of companies offering metallizing services which shows there is considerable experience in Canada. Most companies tend to serve local markets and fall into two categories: those associated with machine shops serving the aircraft, oil and gas, pulp and paper industries, etc. and those offering corrosion control services usually in the field. Although the size of companies covers a wide range the extent of metallizing operations in each company is similar with most firms employing about 2-6 metallizers.

The industry is largely supplier driven with the leading suppliers providing complete metallizing systems, procedures, materials, and technical support. Quality control programs vary widely and emphasize different aspects of the metallizing operation. For example, the corrosion control companies place greater emphasis on blast specifications whereas the machine shops have better material quality control. None of the companies operates a system as complete as that used by the US Navy in its aluminum spraying operations.

The main steps that need to be taken to provide CCG with a reliable metallizing delivery system are in the development of a full quality maintenance system including a draft specification, procedures and field practices, qualification, inspection, reporting and training. CCG would have to work with a limited number of candidate contractors to assist them in reaching compliance.

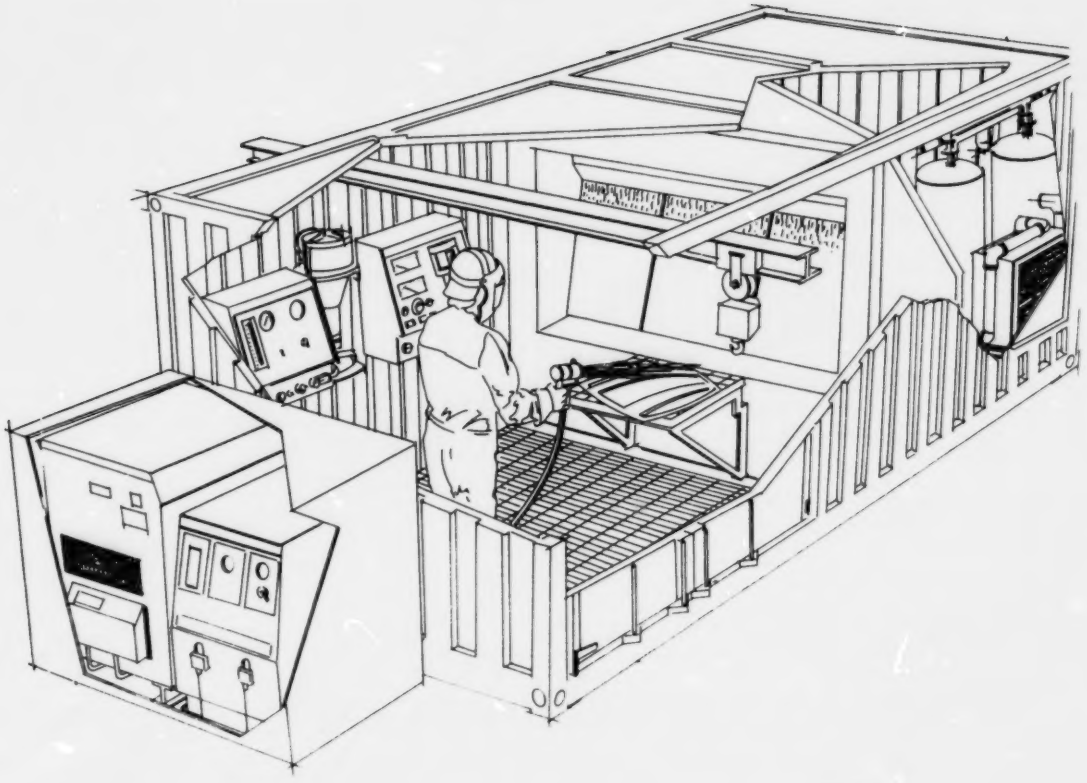


Figure 14. Thermal spray containerized system.

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1) V.Mitrovic-Scepanovic, "Application of Metallizing for Corrosion Control in Marine Environments," CANMET Report MTL 90-4 (CF) March 1990.

2) Suzuki, I, "Corrosion Resistant Coatings Technology," pub. Marcel Dekker, Inc., New York 1989.

3) Sulit, R.A., West, F. and Kullerd, S.L., "Wire-Sprayed Aluminum Coating Services in a SIMA Corrosion-Control Shop," National Thermal Spray Conference, 14-17 Sept. 1987, Orlando, Florida, pub. ASM 1988, pp 241 - 251.

4) Parks, A.R., "Aluminum Sprayed Coatings on Board U.S. Navy Ships—a Ten Year Overview," National Thermal Spray Conference, 14-17 Sept. 1987, Orlando, Florida, pub. ASM 1988, pp 389 - 392.

5) Unger, R.H., "Thermal Spraying of Bridges," National Thermal Spray Conference, 14-17 Sept. 1987, Orlando, Florida, pub. ASM 1988, pp 399 - 406.

APPENDIX A

Standards Relevant to Thermal Spraying

- DOD–STD–2138A(SM)
  "Metal Sprayed Coatings for Corrosion Protection Aboard Naval Surface Ships (Metric)," 23 April, 1986.

- MIL–STD–1687A
  "Machinery Restoration," Feb. 1987.

- CSA–G189–1966(R1980)
  "Sprayed Metal Coatings for Atmospheric Corrosion Protection," (1966, reaffirmed without change 1980).

- AWS C2.2–67
  "Recommended Practices for Metallizing With Aluminum and Zinc for Protection of Iron and Steel," AWS Miami, FL 1967.

- SSPC PS–XMEOOIX–90P
  "Thermal Spray Metallic Coating System," Steel Structures Painting Council, unpublished draft, 1990.

- AWS C2.1
  "Recommended Safe Practices for Thermal Spraying," AWS 1973.

- SSPC–SP5
  "White Metal Blast Cleaning."

- ASTM D4417
  "Standard Test Methods for Field Measurements of Surface Profile of Blast-Cleaned Steel."

- ASTM C633
  "Standard Test Method for Adhesion or Cohesive Strengths of Flame-Sprayed Coatings."

	Company	Address	City	Prov...	Postal...	Contact	Tel	FAX
1	Fused Metals Inc.	239 Armstrong	Georgetown	Ont.	L7G 4X5	Grant Robinson	(416)846-2328	
2	Plastron Spray Inc.	4420-75 Ave. SE. Unit 12	Calgary	Alta.	T2C 2H8	Pres.Tony Short...	(403)236-0506	(403)236-3524
3	Goodman-Brown	924 Southworth. S.	Welland	Ont.	L3B 2A5	George Brown	(416)732-7332	(416)732-5212
4	Feher Machine & Manufactu...	461 Scott. P.O. Box 2320	Sarnia	Ont.	N7T 7L7	Paul Feher	(519)336-5408	(519)336-5422
5	Vac-Aero International Inc.	7450 Vérité	Montreal	Que.	H4S 1C5	Louis Gosselin	(514)334-4240	(514)334-6269
6	Peacock Inc	4737-97 St.	Edmonton	Alta.	T6E 5W2	Harry Kornel	(403)438-1122	(403)437-5218
7	Westcan Engineering & Mac...	2244 Douglas	Burnaby	B.C.	V5C 5A7	Foreman. Helmu...	(604)299-6666	(604)299-5900
8	National Coating Technologi...	1975 Logan Ave.	Winnipeg	Man.	R2R OH8	John Read	(204)632-5585	(204)694-3282
9	Peacock Inc.	1180 Aerowood Dr.	Mississauga	Ont.	L4W 1Y5	Asst.Mgr. Ms. P...	(416)625-7100	(416)625-7203
10	Jacoat Coat Company*	P.O. Box 63	Kingston	Ont.	K7L 4V6	Dave (Radcliffe?)	(613)548-3128	
11	Canada Coating Company	46-48 Eleniak Rd.	Edmonton	Alta.	T6B 2S1	Brad Mason	(403)440-4238	(403)469-8054
12	Grenco Industries Ltd.	9846-60 Ave.	Edmonton	Alta.	T6E 0C5	Art Grenke	(403)438-5070	(403)438-5077
13	Bluewater Machine	469 Campbell. P.O. Box...	Sarnia	Ont.	N7T 7K2	Ron Fournier	(519)336-3614	(519)336-7410
14	Western Engineering Servic...	274 Kingston St.	Thunder Bay	Ont.	P7E 3P7	Lino Rubin	(807)475-0484	(807)475-3645
15	All-Weld Co. Ltd.	29 Passmore	Scarborough	Ont.	M1V 4T1	Jim Holder	(416)299-3311	(416)299-3387
16	Vernon Manufacturing Corp.	Black Diamond Rd. P.O. ...	Belleville	Ont.	K8N 4Z9	Ed Burtt	(613)968-3231	(613)968-7190
17	C.H. Heist Ltd.	20 Depew	Hamilton	Ont.	L8L 7W9	William DeBoer	(416)547-5661	(416)547-0511
18	Plasma & Flame Coating Inc.	924 Southworth S.	Welland	Ont.	L3B 2A5	Rick Brown	(416)732-3136	(416)732-5212
19	Aerospace Welding Inc.	2760 Paulus	Montreal	Que.			(514)331-3428	
20	Métallisation Bergeron Enr. La	199 Gamble O.	Rouyn-Nora...	Que.	G9X 2R8	André Bergeron	(819)762-4631	
21	FB Fab Inc.	1580 Provinciale	Quebec City	Que.	G1N 4A2	Frank Bouchard	(418)687-5000	(418)687-2241
22	Métallisation du Nord Inc.	876 Perrault	Chibougamau	Que.	G8P 2T3	Raymond Lafra...	(819)748-6442	(418)748-7011
23	Fieldco Mfg. (1975) Ltd.	8542-42 St.	Edmonton	Alta.	T6B 2M4	Dwayne Zukowski	(403)465-0565	(403465-0569
24	Maritime Steeplejack Co. Ltd.	R.R. #4, Box 20, Site 11,	Bathurst	N.B.	E2A 3Y7	Maurice Chamb...	(506)546-9373...	(506)548-0081
25	Fairview Industries Ltd.	Lakeshore Industrial Par...	Armdale. Hal...	N.S.	B3L 4K9	Jim Whiteway	(902)876-2325	(902)876-8598
26	Redman Machine & Metallizi...	441 Industrial Rd. P.O.B...	Stn. D. Lon...	Ont.	N5W 5R6	Walter Schwazer	(519)451-9310	(519)451-3124
27	Metal Spray-on Ltd.	649 South Service Rd. ...	Grimsby	Ont.	L3M 4H8	Joe Akers	(416)643-4244	(519)643-4246
28	Sudbury Corrosion Control ...	200 Fielding Rd. P.O. B...	Copper Cliff	Ont.	T0M 1N0	Tom Larin	(705)682-0813	(705)682-2220
29	BV Tool Co. Ltd.	1130 Vanier. P.O. Box ...	Sarnia	Ont.	N7T 7L7	Marijn Bigec-For...	(519)344-9364...	(519)344-3841
30	C.H. Heist Ltd.		Sault Ste. M...					
31	Peacock Inc	2715-18 St. NE	Calgary	Alta.	T2E 7E6	Joe Kulczycki	(403)250-7000	(403)250-6972
32	Moore's Engine Profession...	2320-32 Ave. NE	Calgary	Alta.	T2E 6P4	Dave Emsley	(403)250-7561...	(403)250-5197
33	Abacal Alta Ltd.	8815-44 St. SE. P.O. B...	Calgary	Alta.	T2P 2G6	Mike Denis	(403)279-4911	(403)236-2601
34	Headhunters Diesel Ltd.	16740-110 Ave.	Edmonton	Alta.	T5P 1G9	Keith Ambury	(403)484-5521	(403)484-0484
35	Almac Machine Works Ltd.	9539-56 Ave.	Edmonton	Alta.	T6E 0B2	Rollie Marcotte	(403)434-3402	(403)437-3507
36	Quality Hard Chrome Plating	4263-95 St.	Edmonton	Alta.	T6E 5R6	Jerry McCracken	(403)461-8333	(403)461-8333
37	Applied Materials Technolo...	9545-58 Ave.	Edmonton	Alta.	T6E 0B8	Russ Kuchar/Ch...	(403)434-9598	(403)436-4077
38	PR Galvanizing Ltd.	609-22 Ave.	Nisku	Alta.	P0C 2G0	Lee Nha	(403)955-2059	(403)955-7570
39	Deam Galvanizing Inc	9390-48 St	Edmonton	Alta.	T6B 2R3	Dale Butterworth	(403)468-6868	(403)468-6868
40	Clark and Pattison	P.O. Box 1418	Victoria	B.C.	V8W 2X2	John Clark	(604)652-5233	(604)652-5234

List of metallizing companies

	Company	Address	City	Prov...	Postal...	Contact	Tel	FAX
41	Dynacor Coatings	7753 Berg Rd.	Delta	B.C.	V4G 1B9	John Ilott	(604)946--0136	(604)946-1640
42	Johnson & Neven Ltd.	5577 Byrne	Burnaby	B.C.	V5J 3J2	Bob Callegaro	(604)435-3351	(604)435-5695
43	Celero Galvanic Surface Pro...	2951 No. 3 Road	Richmond	B.C.	V6X 2B2	Robt. Van den B...	(604)276-2526	(604)276-2526
44	Smith Industries (1958) Ltd.	115 W 4th	Vancouver	B.C.	V5Y 1G4	Glenn Cooper	(604)874-6110	(604)874-6027
45	E. Raitt Painters Ltd.	7-12491 No. 2 Rd.	Richmond	B.C.	V7E 2G3	Don Woolard	(604)277-4737	(604)277-1914
46	Western Metallizing Co. Ltd.	128 Bannister	St. James (W...	Man.	R2R 0S3	Sid Ball	(204)694-1055	(204)694-6080
47	Nova Scotia Armature Works...	2453 James	Halifax	N.S.	B3K 3W6	Ed Boyd	(902)429-1590	(902)429-1590
48	C.H. Heist Ltd.		Sudbury	Ont.		Steve Mentrycki	(705)682-2808	
49	C.H. Heist Ltd.		Oakville	Ont.		Roger Plumpton...	(416)842-6920	
50	C.H. Heist Ltd.		Sarnia	Ont.		Gary Stephenson	(519)336-3330	
51	Kirkland Lake Machine & We...	37 Duncan N.	Kirkland Lake	Ont.			(705)567-9244	
52	Harrison-Muir Ltd.	52 Production Drive	Scarborough	Ont.	M1H 2X8	Danny Milford	(416)438-6706	(416)438-1521
53	Clara Industrial Services Ltd.	1130 Commerce St.	Thunder Bay	Ont.	P7C 4X7	Jamie Turcotte	(807)577-7546	(807)475-4051
54	Action Metallizing & Machin...	21 Jutland	Etobicoke	Ont.	M8Z 2G6	Bob Acorn	(416)255-6848	
55	Kent Compressor	County Rd. 42 & L'Espe...	Tecumseh	Ont.	N8N 2M1	Mach.Harry Willia...	(519)735-4979	(519)735-7375
56	Sterling Power Systems Su...	799 Rennie	Hamilton	Ont.	L8H 7L4	Fred Schovanec	(416)547-2345	(416)547-2381
57	Sandrin Bros.	150 Exmouth St.	Sarnia	Ont.	N7T 7J2	Neil Beaumont	(519)336-5588	(519)336-5659
58	Sleegers Machining & Fabri...	406 First (Machine shop)	London	Ont.		Don Perry	(519)451-5480	
59	Alloy Welding Centre Ltd.	38 Elizabeth	Guelph	Ont.	N1E 2X2	John Van Goozen	(519)822-0577	(519)822-9791
60	Jet de Sable Trans-Canada	465 Pl. Trans Canada	Longueuil	Que.	J4G 1P4	Pierre Belliveau	(514)651-6721	
61	Services d'Inspection Anti-C...	330 St. Françcois Xavier	Montreal	Que.	J0L 1G0	Richard Giroux	(514)638-3479...	
62	Huot S Inc.	1000 Ste. Therese	Quebec City	Que.	G1N 4N3	Jean-Guy Coté	(418)681-0291	(418)681-3742
63	Industrie de Métallisation H ...	Rear 1815 le Caron	Montreal	Que.	4HE 1H4	Therese Seguin...	(514)767-1890	
64	Tri-Botechtic Inc.	1245 Michelin	Chomedey (...	Que.	H7L 4S2	Claude Ouillette	(514)629-7205	
65	Protoplast	P.O. Box 310	Cobourg	Ont.	K9A 4K8	John Rolph,Joa...	(416)372-6451	(416)372-4087
66	Faraday Metaltron Corp.	18 Bram Crt. Unit #4	Brampton	Ont.	L6W 3R6	Mike Bruyea	(416)459-8988	(416)459-8999

List of metallizing companies

APPENDIX C
Report of Visits

Company: JaCoat Company (Division of George A. Wright & Son Machine Works Limited)

Address: 146 Hickson Avenue
P.O. Box 63
Kingston, Ontario K7L 4V6
Tel: (613)548-3128 FAX: (613)542-1345

Person seen: David Radford (Manager–plasma coatings)
1 Feb, 1991

The coating activities of JaCoat have grown as an adjunct to the machining operations of the original company which has been in business for over 26 years. The whole company employs about 70 with 3 full-time on thermal spraying activities. All activities are in the shop and they rarely get involved in field work.

Applications:

Most applications are currently for the aircraft industry including gas turbine parts. They do work for the textile industry and have been involved in nuclear components. For the marine industry JaCoat has worked on pump parts, shafts, sleeves, seals, etc. They have a division that works on packaging. Many jobs are small (less than $1,000) although a hopper (~2 m high) was being sprayed during the visit. Many jobs are for life extension.

Facilities:

Two grit blast booths plus another room (~12' × 15') for grit blasting. All air passes through driers.

Two plasma booths for high and low velocity systems. Booths have water wash ventilation systems. One booth has a small lathe for rotating parts. For handling the wide variety of small applications there is considerable improvisation in the setups. Powders are stored in a dry cabinet (not separately heated).

Control systems:

About 70% of the work is termed 'commercial' usually comprising small jobs without detailed documented procedures. Thirty per cent of the work is termed 'qualified' and follows a documented quality system. A formal QA manual is currently under revision.

Procedures are worked out with the customer. The customer's agreement constitutes procedure approval and testing is rarely required to qualify a procedure. Similarly, customers do not require qualificatio.. of operators by testing. An example of a procedure is given. The machine parameters used are documented in detail as in the example shown. Two technicians check each other's work and external inspectors are not normally used. Many jobs required traceability of materials and batch numbers of materials used are recorded. It is common practice for customers to require a 'Certificate of Conformance' (example given). Through-put considerations ensure the time between blasting and spraying is less than one hour although this is not explicitly specified.

PROCESS PROCEDURE FOR CHROMIUM OXIDE APPLICATION (SA-P-106F-89)

1. **PRECLEANING:** Parts shall be degreased using clean solvent for a minimum of 3 minutes. The solvent shall be 1,1,1-trichloroethane (stabilized).

   NOTE: After precleaning and throughout remainder of processing, parts shall be handled with lint free cotton gloves only.

2. **MASKING:** Use appropriate masking technique to mask all areas where coating is not required.

3. **SURFACE PREPARATION:** Grit blast all surfaces to be coated to a white metal condition, with Aluminum Oxide SAE G-54 grit at 60 p.s.i.

4. **INSPECTION:** A visual check shall be made to verify surface finish.

5. **SET-UP:** Mount samples and test tabs (furnished by SPAR) in appropriate fixtures.

6. **PREHEAT:** Samples shall be preheated, 100°-150° C, just prior to coating application.

7. **NICHROME COATING:** A 0.002 to 0.004 inch thick layer of Nichrome shall be applied. Use test tabs only for all visual and dimensional verification.

8. **CHROMIUM OXIDE COATING:** Chromium Oxide coating shall be applied to required thickness, maintaining temperature to 200° C maximum.

9. **INSPECTION:** Verification of Chromium Oxide coating thickness shall be done using the test tabs. Samples shall not be used at this stage.

10. **FINISHING:** Samples shall be subjected to grinding and lapping, or polishing procedures in accordance with SPAR's process procedure. Cleaning shall be performed in accordance with SPAR's cleaning process.

11. **COATING REQUIREMENT:** Final coating thickness shall be 0.010 to 0.012 inch. Coating surface shall be within 0.0003 inches flatness and parallelism to the back surface of the substrate.

12. **FINAL INSPECTION:** The finished surface shall be free from cracks and contamination. Dimensional and visual inspection shall be performed and documented.

13. **PACKAGING:** Samples shall be packaged individually in clean bags, sealed with inert gas and desiccant.

14. **ACCEPTANCE:** Samples will be accepted on the basis of visual, dimensional and cleanliness criteria.

JaCoat Company
Division of George A. Wright & Son Machine Works Limited
146 Hickson Avenue, P.O. Box 63 — Kingston, Ontario K7L 4V6

Metco 9M Plasma Parameters

The following equipment parameters were utilized to process Friction Pads as per drawing 1723-1 and 1723-2 as per spec SA-P-106F-89.

Powder 56F

Nozzle #723
Powder Port #2
Plasma Gas: Argon 100 P.S.I. Flow 150 C.F.H.
Hydrogen 50 P.S.I. Flow 5 C.F.H.
Power: 500 AMP
60/70 Volt
Powder Carrier Flow (Argon) 37
Powder Flow Rate 15 Lbs./Hr.
Gun to target distance 5"

Powder 106F

Nozzle #723
Powder Port #2
Plasma Gas: Argon 100 P.S.I. Flow 80 C.F.H.
Hydrogen 50 P.S.I. Flow 15 C.F.H.
Power: 500 AMP
65/70 Volt
Powder Carrier Flow (Argon) 37
Powder Flow Rate 5 Lbs./Hr.
Gun to target distance 2-1/2"

Workpiece rotational speed 1725 R.P.M.
Gun traverse Rate 15 F.P.M.

JaCoat

Telephone (613) 548-3128

JaCoat Company
Division of George A. Wright & Son Machine Works Limited
146 Hickson Avenue, P.O. Box 63 — Kingston, Ontario K7L 4V6

CERTIFICATE OF CONFORMANCE

To: _____ Date: _____

This certifies that the parts shipped under your Purchase Order # _____ and under JaCoat Co. Shop Order # _____ and under JaCoat Co. Packing List # _____ were processed in conformance with the following specifications and/or instructions.

Specifications: _____

For record and reference purposes, identification of material is as follows:
JaCoat: _____ Batch #: _____

Part or Drawing #: _____ Issue: _____
Description: _____
_____
Serial #: _____
Quantity: _____

Only the work requested has been performed and inspected on the parts identified above. Pertinent details of the work performed at this facility are on file under the Shop Order # and Purchase Order # indicated.

_____
Approved Inspector

Company: Plasma & Flame Coating Inc.

Address: 924 Southworth S.
Welland, Ontario L3B 2A5
Tel: (416)732-3136

Person seen: Rick Brown

This company is also associated with a machine shop with most jobs being undertaken for wear resistance. Their location in Welland allows them to service the S.W. Ontario market which includes the steel industry.

Applications:

About 80% of the work is in ceramics. Jobs include sealing applications for the steel industry, vacuum valves for the canning industry and food industry (although this is declining). For the oil industry they do hydraulic piston rods, sucker rods, valve stems, tungsten carbide overlays, aluminum-bronze overlays on pistons. Most work is in the shop. They have done field work including zinc spraying of bridges although this is not their main line of business. They have undertaken marine work and worked with shipyards (Port Colbourne). Applications include shafts and propellers.

Facilities:

Grit blasting is carried out in a separate (40 ft long) shed. Two compressor systems are available. A moisture removal system is being added because problems had been experienced on occasion with moisture in the air.

Equipment for flame and plasma is available including Metco 10E, 5P, 3M, Eutectic Teradyn 2000, Miller internal head, Metco 4MP fluidized bed powder feed unit. The spray area has water wash exhaust system and a lathe and turntables are available for rotating parts.

In the finishing department components up to 22 in. diameter and 10 ft long can be diamond ground.

Control systems:

Procedures are worked out with clients on an individual basis but the company uses a standard procedure as a base (example). They may use supplier information for specific procedures. In some cases procedure details are specified on customer drawings (example shown).

When required they measure the anchor pattern profile to verify blasting procedures.

The 'Certificate of Compliance' (example shown) approach is used with many clients. External inspection is not normally used. Since most coatings are machined or ground, the main final inspection is dimensional.

Plasma & Flame Coating Inc.

924 Southworth Street, South
WELLAND, ONTARIO L3B 2A5
Phone 732-3136

STANDARD PROCEDURE TO DEPOSIT COATINGS ON STEEL SUBSTRATES

1. Chamfer all edges to be coated. 1/16" (1.5mm) x 45 degrees minimum.
2. Degrease thoroughly. 1.1.1 Stabilized Trichlorethane Vapour as required.
3. Mask areas not to be coated. A mechanical mask or rubber tape can be used.
4. Blast with 20-40 grit angular Aluminum Oxide 70 P.S.I. air pressure minimum. Use only sharp, coarse, clean abrasive.
5. Mount work in a rotating device such as a lathe or turntable. 35 SFPM minimum.
6. Mask areas not to be coated, either with Metco Anti-Bond or with a mechanical mask. Do not use oil-base welding anti-splatter.
7. Preheat to a maximum of 150 degrees F. (65 Deg. C.), using the gun or a torch.

   NOTE: Oil in any form cannot be tolerated at this point. If the presence of oil is noticed, repeat steps 2 - 7.

8. Bond coat - apply Metco 405 bond coat with the Metco 10E Metallizing System .005" - .007" (.13 - .18 mm) using the 10E parameters provided in the Wire Spraying Data Sheet, the 10E Instruction Manual or Technical Bulletin.
9. Apply Metco Metcoloy's, thickness as required, with the Metco 10E Metallizing System, using the 10E parameters as provided in the Wire Spraying Data.

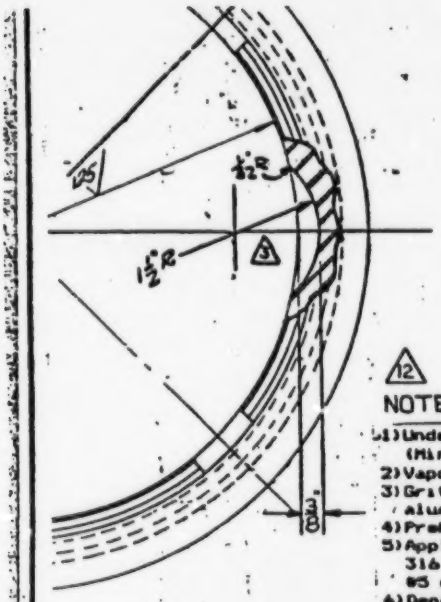
   NOTE: Keep the part temperature below 350 Deg. F. (176 Deg. C.). Interrupt spraying, as required, and use the Metco AJ Siphon Air Blast.

10. Allow part to cool to room temperature in calm air. Remove Metco Anti-Bond and/or mechanical masks.

8. Apply Eutectic 21021 (thickness as required), with the Terodyne System 2000 using the parameters provided in the Instructions Manual.

   NOTE: Keep the part temperature below 350 Deg. F. (176 Deg. C.). Interrupt spraying, as required, and use the Metco AJ Siphon Air Blast.

9. Allow part to cool to room temperature in calm air. Remove Metco



12

NOTE A:

1) Undercut outside dia. (Min: 0.025" THK)
2) Vapour degrease entire part
3) Grit blast with angular aluminum oxide grain
4) Preheat (150-200 F)
5) Apply bond coat of proprietary 316 stainless steel - Metroloy 85 or equivalent (Max: 0.018" THK)
6) Deposit chromium oxide ceramic (Metro 136 F, Eutectic 18926 or equivalent) using Metro 3M Plasma System (Min Ceramic Overlay Finish: 0.007" THK)
7) Seal with air drying phenolic
8) Finish grind outside dia. to 16

SUBJECT INDEX No.											SERIAL No.		REV
0	4	3	5	2	5	0	0	5	0	1	1	2	

NOTE: THIS DWG. SUPERSEDES
P008 ON DOM. ENG. DWG 32R510021 &
P003 ON 32R510025

AREST DEW 32R508101

REF. - B-11476.
REF: DOM. ENG. DWG. 32R510007
KEY DETAIL - 32R510021 P010

Fm 74-04
82679

REQ'N No.

. LTD.

SPECIAL STEELS DIVISION

N° 5-56' & N° 1-66' COLD MILL
WORK ROLL CHOCKS
ADJUSTING RING DETAIL

DRAWING NUMBER
B-13825

LAST DIGIT OF DRAWING NUMBER CHANGES AND CORRESPONDS WITH THE REVISION NUMBER

TYPE 1 REV. 11/74

Plasma & Flame Coating Inc.

924 Southworth Street, South
WELLAND, ONTARIO L3B 2A5
Phone 732-3136

July 29, 1985.

CE Bauer Co. Ltd.,
435 Elgin Street,
Brantford, Ontario.
N3T 5S4

Attention: Mr. Jim Morrison.

RE: CEX-01598 Mounting Sleeves, Bauer P.O. # 59170.
One piece inspected and shipped July 24/85 on Plasma & Flame Coating shipping bill # 427.

CERTIFICATION OF MATERIALS:

Metco 105 White Alumina Powder
EMS 52432 Class VI
PWA 1310 Lot # 22673
Identification # 4013

CERTIFICATION OF DEPTH AND CONCENTRICITY:

Minimum .015" thick checked with FM Positest conforming to ASTM A 153-61, ASTM A 368-61, ASTM D 1186-53 (1973) B.S. 5411 Part II, DIN 5098 1 & 2, ISO 2178-1972, SSPC-PA 2-73T.

Undercut checked with dial indicator ±.001" concentricity with finished bore.

Ceramic inlay checked with dial indicator before finishing ±.001". (Plasma deposition is inherently concentric).
Final inspection of concentricity at your plant.

Yours truly,

Richard J. Brown
per DB

Richard J. Brown.

RJB:db

Company: Metal Spray-on Ltd.

Address: P.O. Box 430
South Service Road
Grimsby, Ontario L3M 4M8
Tel: (416)643-4244 FAX: (416)643-4246

Person seen: Joe Akers and Terry Akers

The company specializes in metal coatings including electroplating and thermal spray coupled with machining and grinding/polishing finishing capabilities. The business is housed in a modern 12,500 sq.ft plant. Plating facilities include tanks up to 13 ft deep. They have been in operation for about 20 years.

Applications:

Much of the spray business is for the steel industry including shafts and rolls. Seal rings for pipes are also done. They have done aluminum and zinc spraying including extensive field work on CN railway bridges. Aluminum spray has been used on aluminum molds for die casting.

Facilities:

A large (10 m × 5 m) blast room is available. Blasting is with 'White Lightening,' 'Black Beauty,' or alumina as required. Two compressor systems are available (Hydrovane and 25 HP dual head piston) with large reservoir which assists in moisture capture. Equipment for flame and arc spraying is available including Metco 6RG, 400 amp Miller, and Terodyn 2000. New equipment is currently being purchased. Inspection equipment includes ultrasonic thickness gauge that can measure r.m.s (i.e., profile) and provide hard copy printout.

Control systems:

The main method is an informal system of monitoring by close direct supervision by the technical manager. Many features of a procedure cannot be written down. For example, operators listen to the sound and make adjustments accordingly. Procedures are derived from customers or supplier or they develop and propose their own. No examples were available. They have been successful in suggesting innovative solutions to problems. Final inspection is often primarily dimensional.

Company: Norev Canada Incorporated

Address: 169 Fielding Road
P.O. Box 651
Copper Cliff, Ontario P0M 1N0
Tel: (705)682-0813 FAX: (705)682-2220

Person seen: Ken Decker (President) and Tom Larin

NCI is the new name for three companies: Northern Industrial Refractories, Norev Sandblasting, and Sudbury Corrosion Control which undertakes thermal spraying. They have been in operation for 10 years. Most work is field work and although generally in Northern Ontario they are looking to establish a national and international presence. Employment ranges from 30 to 150.

Applications:

They do work for the mining, smelting, and pulp and paper industry including tanks, acid plant, hoppers, rolls, cyclones, and pump sleeves. They have undertaken much zinc spraying for MTC and CP bridges. They have undertaken work for CCG involving nylon spraying of a buoy.

Facilities:

NCI has field facilities including scaffolding, electrical splitter panels, etc., and portable blasting equipment with compressors up to 750 cfm. A 500 gallon reservoir is used for drying and draining air with separators on the spray equipment. Up to 3 spray guns could be run simultaneously if warranted. Spray equipment includes flame and arc systems: Metco 4RG's, 6RG's, Metco 10E, 12E (flame), Alamo PG55 (powdergun, oxyfuel). Until recently they had a robot which was sold for reinvestment in new equipment for field use.

Control systems:

Procedures are documented and the staff are very familar with industry specifications currently being developed. Ken Decker sits on a SSPC committee that is writing the guide for thermal spray metallic coating systems (SSPC PS-XMETOIX-90P). Jobs would use an inspection checklist as a control (example shown). This requires details of environmental conditions such as humidity and temperature to be measured and recorded. This system allows the use of external or customer inspectors if required. NCI do their own NDT including UT thickness measurements if required. Procedures are not normally qualified by

test although sometimes test panels are made and examined metallographically. Certificates of Compliance are issued if required by the customer. Staff have been trained on-the-job and also through supplier training programs (Metco Technological Institute).

COATINGS INSPECTION CHECK LIST

PROJECT_____ DATE_____

LOCATION_____ UNIT OR AREA_____

AMBIENT CONDITIONS

Air Temperature_____
Metal Temperature_____
Rel. Humidity_____
Precipitation and time after Application_____
Wind Velocity_____
Other Affecting Conditions_____

SURFACE PREPARATION

Surface Condition_____
Cleaning Method_____
Abrasive_____
Blast Profile_____
Sharp Corners Ground_____
Degree of Cleanliness When Application Started_____
Area Cleaned_____
Abrasive Used_____
Area Cleaned to Date_____
Abrasive Used to Date_____

EQUIPMENT

Airless Pump Make and Model_____
Pump Ratio_____
Tip Size_____
Reversible Tip_____
Conventional Gun Make and Model_____
Fluid Tip_____
Air Cap_____
Agitated Pressure Pot_____
Fluid Pressure_____
Atomizing Pressure_____
Water Trap_____
Gun Elevation From Pot_____
Equipment Internal Cleanliness_____

COATING

Product and Codes_____
Thinner_____
% Reduction_____
Wet Film Thickness_____
Dry Film Thickness_____
Sagging_____
Mud Cracking_____
Appearance_____
Curing Time_____
Curing Time Before Handling or Placed in Service_____
Handling Method_____
Handling Damage_____
Damage Touch-up_____
Area Coated_____
Coating Used_____
Area Coated to Date_____
Coating and Thinner Used to Date_____

REMARKS

INSPECTOR_____

CONTRACTOR_____

CLIENT_____

Company: National Coating Technologies Inc.

Address: 1975 Logan Ave.
Winnipeg, Manitoba R2R 0H8
Tel: (204)632-5585 FAX: (204)694-3282

Person seen: John Read (Vice-President and General Manager)

The company used to be known as Plasma & Flame Coatings Ltd. and has recently undergone a change of ownership. It has been in business for 20 years serving mainly the aircraft, mining, and pulp and paper industries. It employs 14 people of whom 4 are full time metallizers.

Applications:

Aircraft applications include intermediate pressure (IP) chambers and after-burners. The former is an aluminum housing about 1 m diameter requiring considerable masking before blasting and spraying. Proprietary abradable coatings are used. After-burners require acid dipping to remove prior coats then are prepared for bond coating and final coat. The company also makes a special rod used in the pulp and paper industry. It is about 7 m long and is sprayed and ground.

Facilities:

Blasting is done in small glove boxes when size permits but the company has a large, sophisticated blast room (about 7 m × 10 m × 5 m) complete with an auger floor for recirculating grit. Rods are blast in a small unit surrounding the rod which feeds through. A new Demonox air purification unit has been installed to provide operator breathing air. Blasting air passes through a charcoal filter for cleaning.

Spray equipment includes flame and plasma including Metco guns, Thermal Spray 5P, Metco 2MC's, 3MP powder feed units and Tepco 7102 powder feeder. Spraying of rods takes place in a special room with water wash extraction. The plasma gun is mounted on a track and moves along the length of the rod as it rotates. Separate spray rooms are used for other applications and include positioners and rolls for rotating components.

Control systems:

The quality systems have been set up largely in response to the requirements of the aircraft industry (Bristol Aerospace Limited). A formal quality assurance (QA) manual has been prepared. Procedures are documented and approved by the cus-

tomer before use. In most cases they are customer supplied with each customer (e.g., Bristol, GE, Pratt and Witney) having its own specifications. Qualification of procedures is through testing involving making test panels which are submitted to the client for evaluation. National Coating Technologies Inc. is planning to set up its own laboratory which will allow it to do its own testing.

Details of procedures are contained in Work Process Sheets (WPS), an example of which is shown. Materials are traceable and batch and lot numbers are recorded. A separate area with a heated storeroom is used and all certified (traceable) materials are stored there. Customers usually require a Certificate of Compliance (example shown) which documents material lot numbers.

Inspection is mainly visual except when dimensional checks following grinding are required. Adequate blasting is judged visually with no requirement for profile checks. Informal tests on coatings such as the knife peel test are sometimes done. Dimensional checks are recorded in an inspection report. Production test panels are often required to be sprayed at the same time as the job and these are returned to the client for evaluation.

Operators are also required to be qualified which is done by test and mechanical evaluation following a specified procedure. An example is given. This qualification remains in effect as long as the individual does not stop spraying for a significant length of time.

OPERATOR SIGNATURE:
INSPECTION STAMP:
DATE OF INSPECTION:

DATE WORK PERFORMED:
UNIT INSPECTED BY:

WPS#
SHEET 1 of 1
DATE

plasma & flame coatings ltd.

1975 LOGAN AVENUE, WINNIPEG, MANITOBA R2R 0H8 — TELEPHONE (204) 632-8585

CUSTOMER AEROSPACE LTD. P.O.#
DWG.#

SUBJECT To Plasma spray Ring & Flowpath - LH 1600
Per SCAS 86090

PART# L41067-901 OUR W/O#
S/N

LAB APPROVED
Sig. 14/05/90

WORK PROCESS SHEET

ITEM#	WORK PARAMETERS	SPECIFICATIONS
1.	MANUFATURER'S POWDER NUMBER	Amdry 500, Cl. 'B'
2.	POWDER BATCH NUMBER	
3.	PLASMA GUN/MAKE & MODEL	METCO: MR: 3
4.	GAS # 1 TYPE - Argon	PRESSURE: FLOW: 75
5.	GAS # 2 TYPE - Hydrogen	PRESSURE: FLOW: 15
6.	GUN NOZZLE TYPE:	GH
7.	GUN POWDER PORT.	#2
8.	GAS DISTRIBUTION RING	Yes
9.	POWER.	AMPERAGE: 500 VOLTS: 60-70
10.	METER WHEEL	L
11.	METER WHEEL R.P.M.	START: 30 ACTUAL:
12.	CARRIER GASFLOW	37
13.	SPRAY DISTANCE	2.5
14.	SPRAY RATE	POUNDS PER HOUR: 4.0 - 6.0
15.	PART R.P.M.	500
16.	PREHEAT TEMPERATURE	No Preheat
17.	METHOD OF COOLDOWN - AJ Siphon Air	Ring Only
	- Air Jet Unit	Crossed at 4.5/40 P.S.I.
18.	GRIT SIZE AND TYPE	54 Mesh/Aluminum Oxide
19.	BLAST TYPE AND PRESSURE	Pressure Pot /35 P.S.I.

TEST COUPONS: 1 Required
TYPE OF MATERIAL: Mast X
180° Bend Test
.002 - .003

DIMENSIONS:
LENGHT: 4.5"
WIDTH: 1.0"
THICKNESS:

THICKNESS AFTER COATING:

Nº 4356

NATIONAL COATING TECHNOLOGIES INC.
(Plasma & Flame Coatings)
1875 LOGAN AVENUE, WINNIPEG, MANITOBA R2R 0H8
TELEPHONE (204) 632-5585
TELEX 07-55544

November 8, 1990

CUSTOMER:
... Aerospace Ltd.
P.O. Box
Winnipeg, Man.
R3C 2S4

Attn: Pat Sawyer, Sub Contract

CERTIFICATE OF COMPLIANCE

PLASMA & FLAME COATINGS LTD., HERE BY CERTIFY THAT THE ITEMS DESCRIBED AS FOLLOWS:

P.F.C. WORK ORDER: 10479-101 YOUR PURCHASE ORDER: 73779

QUANTITY:	PART NUMBER:	DESCRIPTION:
		To Plasma spray IAW S.C.A.S. 00065, Issue 'B'
	3109032-01	
1 only	BI09032-01	L/T Stator Suppt. - R/T 746W0
	Your P/S P88759	Our D/S #0075
		Powder: AMD 956,Lot #190842
		A.I. 1018, Lot #PP-551-90
Two Test Coupons included		
	ADDITIONAL INFORMATION:	Please refer to our Work Process Sheet #3096
	held in our office files.	Work performed by B. Barley.

HAVE BEEN PROCESSED/MANUFACTURED AND INSPECTED TO CONFORM TO THE SPECIFICATIONS, SUPPLIED BY YOUR COMPANY. THIS IS SUBSTANTIATED BY OUR OWN SURVIELLANCE AND/OR BY SATISFACTORY OBJECTIVE EVIDENCE RETAINED IN OUR FILES.

AUTHORIZED SIGNATURE

R Kapke

P.F. No. 0001

aerospace limited

REPORT NO. 82,352

SHEET 1 OF 1

DATE March 15, 1982

ENGINEERING LABORATORY REPORT

SUBJECT OPERATOR QUALIFICATION FOR PLASMA SPRAYED COATINGS

PREPARED BY D. Jenkinson ISSUED BY

APPROVED BY S.R. JOSHI

INTRODUCTION -

Qualification tests for Plasma Sprayed Coatings were carried out to G.E. Specification P28TF2 for Plasma & Flame Coatings Limited.

OPERATOR: BRUCE BARLEY

CODE: A1

COATING THICKNESS: .003" - .005"

COATING MATERIAL: B50TF56 TRADE NAME - METCO 450

BASE MATERIAL: INCO 722 - BOND STRENGTH
1020 CARBON STEEL - MICRO EXAMINATION

TESTS - [3] BOND STRENGTH: I.A.W. E50TF60
[2] MICRO EXAMINATION: I.A.W. E50TF65

TEST RESULTS -

BOND STRENGTH

	LOAD ATTAINED	LOAD REQUIRED(psi)	POSITION OF FAILURE
[1]	6260	2750	COATING
[2]	5400	2750	COATING
[3]	6160	2750	COATING

MICRO EXAMINATION - E50TF65

- VOID CONTENT - Not exceeding U-1 to U-4
- OXIDE CONTENT - Not exceeding X-1 to X-3
- INTERFACE VOID & OXIDE CONTENT - Not exceeding I-1 and I-2
- UNMELTED PARTICLE CONTENT - Not exceeding P-1 and P-2
- CRACKING - None
- DELAMINATIONS - None

CONCLUSION -

The results of the tests conducted on the samples submitted for operator qualification are ACCEPTABLE to the requirements of G.E. Specification P28TF2.

Company: Canada Coating Company

Address: 4648 Eleniak Road
Edmonton, Alberta T6B 2S1
Tel: (403)440-4238 FAX: (403)469-8054

Person seen: Donald Bosch

Canada Coating Company (Cancoat) is a division of L.P.M. Machines Ltd. specializing in plasma spraying for wear resistant coatings. The company has about 4 people as full time sprayers and has about 10 years experience.

Applications:

Most jobs are for the oil industry including down hole tubulars, shafts, pumps, impeller housings, and centrifuges. A wide range of materials are sprayed including tungsten carbide, ceramics, and pure metals. Many applications require novel coatings for corrosion resistance in sour service environments. Clients include companies such as Esso, Syncrude, and Suncor. They have done some sea-water applications, aluminum but little zinc.

Facilities:

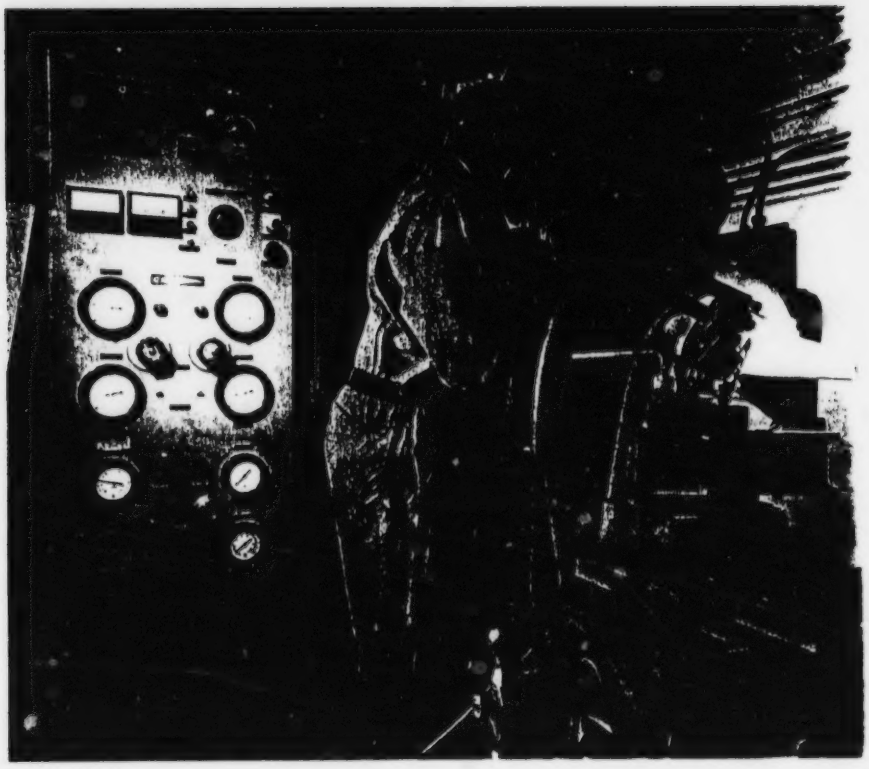
Blasting is in a selfcontained unit with grit recycling. Air supply includes reservoir and drying units. Spray equipment includes Miller (Plasmatron) SJ200 (Mac 1 & Mac 2) and a 80 kW (Mac 2) system. Two rooms (about 4×7 m) are available with soundproofing and controls on the outside. Equipment is set up on lathes and can operate automatically with the operator outside the room. One example is shown.

The large machine shop with 6 large lathes also includes a Superfinish diamond grinding equipment.

Control systems:

Procedures are usually determined by the client. Some clients approve procedures on the basis of tests involving making test panels and client evaluation. This could include weight loss (corrosion) and wear tests as well as the mechanical tests for bond strength. Some clients also require traceability of materials. Inspection is generally visual except for dimensional checks on finished components.

There is no formal qualification of operators but the company uses internal training, job progression, and supplier support for developing operator skills.



View of spray room at Canada Coating Company.

Company: Peacock Inc.

Address: 4737-97 St.
Edmonton, Alberta T6E 5W2
Tel: (403)438-1122 FAX: (403)437-5218

Person seen: Harry Kornel

Peacock is one of the few national companies having operations in Mississauga, Montreal, Calgary, and Edmonton. The latter plant was visited. It is a large machine shop in a modern building employing about 74 people. Metallizing employs 3 people on each of 2 shifts, 7 days a week. Metallizing services are housed in a separate section of the main shop.

Applications:

The Edmonton shop mainly serves the oil industry with refurbishing of down hole tubulars, cylinder sleeves, pumps, babbit bearing, and impellers. One application involves building up worn parts of a centrifuge bowl (for tar-sands). Following spraying the unit is straingauged and spun at 4,800 r.p.m. to assess balance. All work is in the shop and they do not generally undertake field work.

Facilities:

Blasting is either performed in a small grit blast box or with portable equipment. Two rooms are used for spraying and flame, arc, and plasma processes are available. There is a high volume of work (1 ton of powder and 5 tons of wire sprayed per year). Equipment includes JetKote, high velocity system.

Control systems:

Extensive quality systems and documentation are in place. There is a formal QA manual and they are registering to ISO 9000. A typical metallizing preparation report and a spray report are shown. Materials are traceable whether or not the customer specifically requires it.

Inspection is carried out by a separate department. Ultrasonic examination is done on critical applications which is effective in revealing large voids. Most jobs require final demensional checks and r.m.s. (profile) measurements.

METALIZING PREPARATION REPORT W.O. # _____

CUSTOMER: _____ DATE: _____

JOB DESCRIPTION: _____ PREPARED BY: _____

SKETCH

INITIAL: _____

AREA	SIZE FOUND	UNIT	PREPARATION SIZE STYLE	PREPARED DIA.	LENGTH	UNIT	TYPE OF SPRAY	UNIT	MACHINING SIZE	UNIT	SIZE FINISHED TO	UNIT
A												
B												
C												
D												
E												
F												
G												
H												

UNOUT: _____ RECENTERED (1) _____ (2) _____

MACHINE USED TO FINISH: _____

REVISED: AUGUST 09, 1989 **SPRAY REPORT**

CUSTOMER: _____ W.O.# _____ DATE: _____

PARTS DESCRIPTION: _____

OPERATOR: _____ BOND: _____ COATING: _____

LOT OR HEAT #: BOND: _____ COATING: _____

SEALER: _____ MARKINGS: _____ QUANTITY: _____

PREPARATION: _____ GLASS BLAST: _____ GRIT BLAST: _____

DIA X LENGTH	FINISH	PREPARED	SPRAYED

EQUIPMENT:	GUN	EXT.	NOZZLE	AIR CAP	POWDER PORT	METER VALVE

BOND: _____

COATING: _____

GAS TYPE: OXY ACETY PRIMARY SECONDARY

BOND: _____

COATING: _____

PRESSURE: OXY ACETY AIR PRIMARY SECONDARY

BOND: _____

COATING: _____

FLOW METER OXY ACETY AIR PRIMARY SECONDARY

BOND: _____

COATING: _____

POWDER FEED: FLOW WHEEL VIBRATOR RPM DIAL FEED RATE

BOND: _____

COATING: _____

POWDER: VOLTS AMPS SPRAY DISTANCE RPM FLOW

BOND: _____

COATING: _____

MATERIAL: BOND: _____ COATING: _____

Company: Johnson & Neven Ltd.

Address: 5577 Byrne Road
South Burnaby, B.C. V5J 3J2
Tel: (604)435-3351 FAX: (604)435-5695

Person seen: Bob Callegaro and Glen Johnson

Johnson & Neven Ltd. specializes in corrosion control including sand blasting, painting, special coatings, and metallizing. It has been in operation for 40 years. Staff are active in the National Association of Corrosion Engineers (NACE), Steel Structures Painting Council (SSPC) and other industry associations. Both shop and field work are undertaken.

Applications:

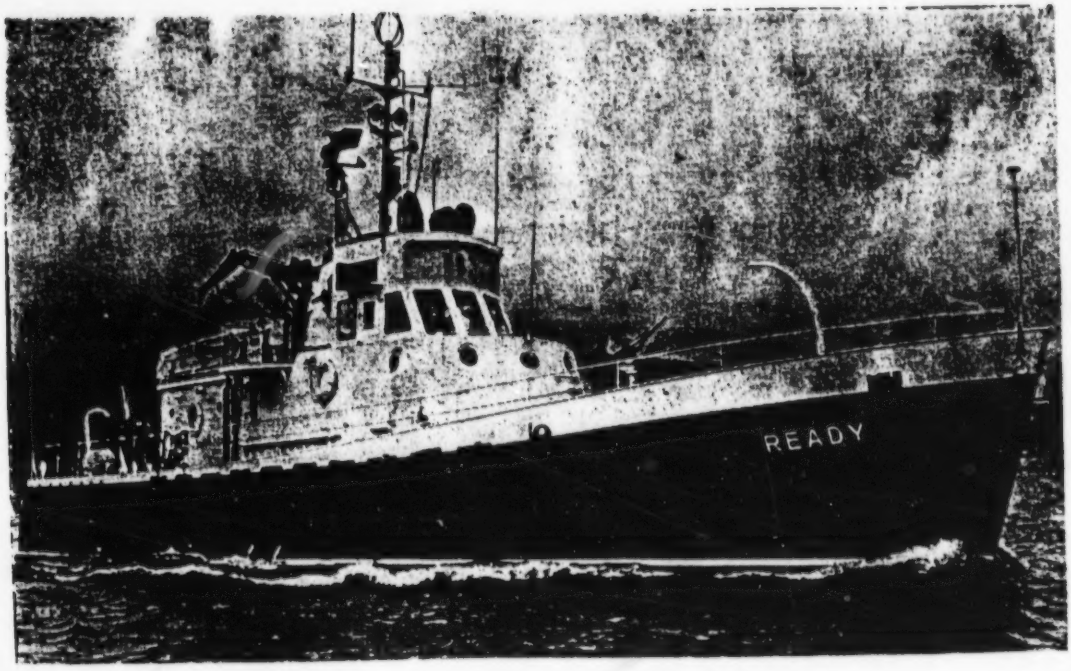
The main industries served are pulp and paper, chemical, oil and gas, highways, rail and shipping terminals. Of special relevance is the work done for the shipping industry and previous CCG work. They have metallized a number of hulls of fishing boats and several years ago (1963) metallized the CCG cutter 'Ready'. This was coated with zinc. Aluminum has also been used on a ship loader at a bulk terminal. In the original job 6~8 mils was specified and after 20 years the measured coating was 5~7 mils. Examples are shown.

Facilities: All spraying equipment is Metco guns, most are 10E's since most field work uses flame spraying. A full range of field equipment including compressors, scaffolding, sand blasting, etc., is available.

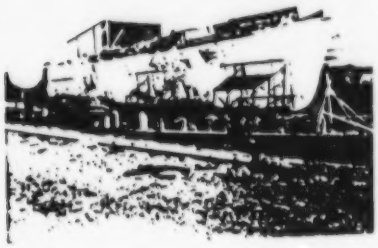
Control systems:

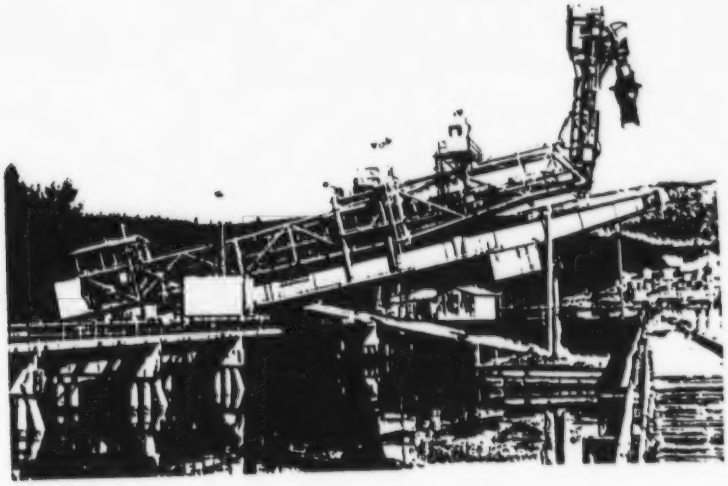
Procedures are ususally defined in bid documents and separate approval or qualification is not normal. These often define environmental conditions under which spraying may not be permitted, e.g., if the relative humidity exceeds 85%. Certificates of Conformance are not normally requested but it is common to have external inspectors. The quality of the blast finish is usually inspected visually using comparison charts when necessary. Thickness is checked after coating using standard thickness gauges. Inspection reports are not normally required.

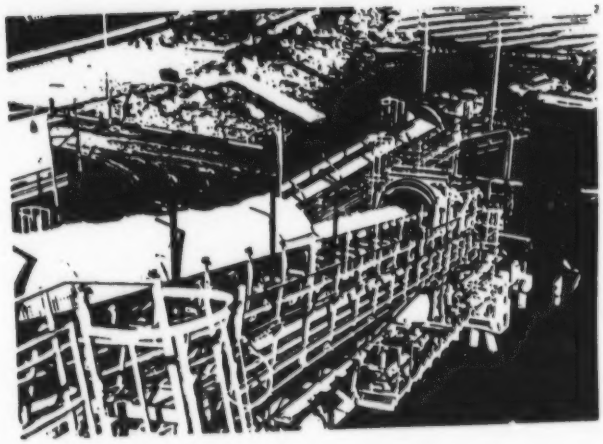
There is no formal qualification system for personnel although each holds some trade certificate (although metallizing itself is not a regulated trade).

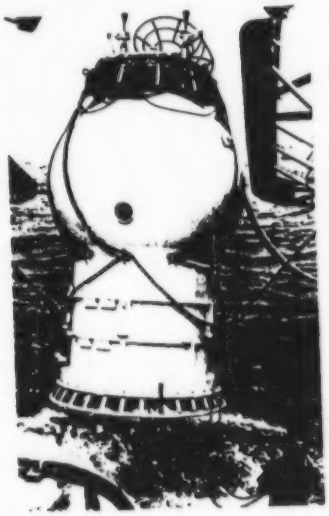


Coast Guard Cutter Ready metallized with zinc in 1963.









Typical marine applications where metallizing has been used (Johnson & Neven Ltd.

Company: E. Raitt Painters Ltd.
Address: #7-12491 No. 2 Road
Richmond, B.C. V7E 2G3
Tel: (604)277-4737 FAX: (604)277-1914

Person seen: Don Woollard and Ed Raitt

The company are painting contractors employing up to 45 people on a seasonal basis, of these 5 or 6 would be involved in thermal spraying. All work is done in the field. They have about 7 years experience in metallizing.

Applications:

The major application is bridges and they have completed many for Canadian Pacific Rail. Bearing parts and connections and other areas of limited access are metallized since they would be inaccessible for painting in service. Highway bridges, railings, etc., are metallized up to 3.5 m above the deck (the splash zone). All work is with zinc.

Facilities:

All work is done with Metco flame spray equipment and they have the full range of portable equipment, compressors, etc., for field work. Air driers and coolers are used for blast air. Blasting is usually done with silica sand.

Control systems:

General procedures are normally defined in bid documents (example shown) and specify blast quality and coating thickness. Limits on environmental conditions may also be set. Temperature and humidity are recorded daily. Blast profile is inspected visually using the SSPC pictorial standards.

Large jobs are divided into smaller areas in order to control the time between blasting and spraying. Spraying is done on the same day as blasting but shorter times may be specified. A test panel may be made to show the blast quality for the particular material being used and this would serve as a standard for subsequent inspection. It is common for clients to ask for profile measurements of the blast surface. External (independent or client) inspectors are normally employed and these are usually specialists in coatings inspection. It is common to require mechanical testing (SSPC pull test) of coatings.

There are no formal qualification requirements for personnel but customers sometimes ask for evidence of experience.

4. Drawings

The following half-size drawings accompanying these provisions are:

Drawing No. 299 - 1 Beams Approach Spans
- 2 Floor Beams and Stringers
- 11 Bottom chord
- 13 Layout
- 31 Sidewalk Addition

5. Specifications

Unless otherwise stated in the Special Provisions, Painting of Structural Steelwork shall be in accordance with Section 216-11 of the Ministry's General Specifications

6. Area A - Cleaning

Areas to be metallized shall be blast cleaned to SSPC-SP5 (white metal blast cleaning) as defined by SSPC-Sa.3. pictoral standards. These areas are not necessarily continuous, and spot blast cleaning and metallizing will be required in various parts of the bridge. These areas shall be defined by the Engineer, but are primarily the faces of the vertical and diagonal members facing the oncoming traffic, parts of the outside stringers and lower chords, and the steel work on and around the bearings. All exposed edges of sound paint shall be properly feathered to the satisfaction of the Engineer.

The timber sidewalk and rails shall be protected from damage due to over-blast during cleaning.

7. Area A - Metallizing

Metallizing (thermal spraying, flame spray process) shall be in accordance with CSA Standard G189-1966. The metal coating shall be applied using zinc wire from approved sources. All metallizing equipment shall be approved by the Engineer before work commences.

Areas that have been blasted to white metal, as defined above, shall be coated no more than 4 hours after cleaning. Before metallizing, areas that have been blasted shall be approved by the Engineer. The average thickness of application shall be 0.15 to 0.2 mm (6 to 8 mils). This is approximately equal to a coverage of 1.15 kg./sq. metre.

The transition area between the metallized surface and the existing paint shall be cleaned using normal methods, and then primed using carbomastic 15 or approved similar paint.

The freshly metallized surface shall be given a single coat of vinyl aluminum paint (Polyclad 936 aluminum 901 or approved equal) thinned by 50 percent and allowed to dry before final coat of paint is applied.

$= 419\ M^2 \times 1.15 = 482\ KG \times 2.20\ lbs = 1061\ lbs$

Company: Dynacor Coatings

Address: 7753 Berg Rd.
Delta, B.C. V4G 1B9
Tel: (604)946-0136 FAX: (604)946-1640

Person seen: Don Braun

Dynacor specializes in coating application including sand blasting, painting, special coatings, and metallizing. They maintain a large shop but also do a substantial amount of field work. They employ up to 80 people on a seasonal basis and have 10 metallizers.

Applications:

The main industry served is the pulp and paper industry and they also do bridges and other structural steel. A common application is the zinc spraying of components too large to be completely galvanized. In the past 18 months about 80,000 lbs of zinc was sprayed.

Facilities:

Spray equipment at present is all flame system (Metco 10, 11, 12 guns) but they are currently looking at arc systems. Air for blasting is passed through a large 1,000 cfm dessicator. This is considered necessary for jobs on the waterfront where the humidity is high.

Control systems:

Procedures, including those for safety are documented. Blast quality is inspected visually with the SSPC pictorial standards. Blast profile would be measured at the beginning of a job to verify parameters. For SSPC #5 or #10 the grit would not be recycled to ensure the correct anchor profile was being maintained. Environmental conditions, temperature, and dew point are monitored. Time between blast and spray is controlled.

Independent inspectors are retained by the customer for the purpose of checking procedures, humidity, and final coating. Final inspection is mainly visual and thickness check (with magnetic gauge), and informal tests (such as tapping). Inspection reports are issued. In addition to external inspectors the company has on staff 2 NACE qualified inspectors.

Qualification of personnel is not required by customers but the company has its own in-house training scheme and only experienced metallizers would be assigned to critical jobs.

Company: Fairview Industries Ltd.
Address: Lakeside Industrial Park
P.O. Box 924, Armdale
Halifax, NS B3L 4K9
Tel: (902)876-2325 FAX: (902)876-8598

Person seen: Jim Whiteway

Fairview is a machine shop and fabricating shop that has thirty years experience in metallizing.

Applications:

The company has undertaken a variety of metallizing applications including bridges and similar structures as well as marine applications and work for DND. Typical of the latter are shaft repairs requiring build-up of wear surfaces using 316 stainless steel. Zinc and bronze are also commonly sprayed but not aluminum.

Facilities:

Spray equipment is all flame system (Metco guns) since portability is a requirement. Air for blasting and spraying is passed through a two-component drying system. Blasting is done with silica sand or grit (e.g., Black Beauty). Of a staff of 45 they would have up to twelve sprayers.

Control systems:

Spray procedures are documented using standard welding data sheets as the format. Procedures are normally worked out with Metco. Some clients require approval of procedures but normally no testing is required. No facilities are available for mechanical or non-destructive testing. No special cleaning procedures are used.

On some jobs material traceability is required and this is done although there is no separate storage room for materials. Clients do not require qualification of sprayers but their sprayers are usually certified welders.